NRG 34 m TallTower™
Installation Manual & Specifications

Global leader in wind measurement technology

110 Riggs Road · Hinesburg · VT 05461 USA · TEL (802) 482-2255 · FAX (802) 482-2272 · EMAIL sales@nrgsystems.com

Specifications are subject to change without notice.

Installation of guyed towers is inherently dangerous. To minimize risks, read and follow the tower installation instructions explicitly. Do not install during an electrical storm. Installation in agricultural areas may pose a threat to low flying crop dusting aircraft. Notify appropriate parties and install warning devices as needed. We assume no responsibility or liability in connection with any act, error, omission, or for any injury, loss, accident, delay, inconvenience, irregularity or damage related to any TallTower installation.

DANGER: YOU CAN BE KILLED

IF THIS TOWER COMES NEAR ELECTRIC POWER LINES or IF YOU INSTALL THIS TOWER DURING AN ELECTRICAL STORM.

FOR YOUR SAFETY, FOLLOW THESE INSTALLATION INSTRUCTIONS.

Table of Contents

WARNINGS 6
Do these things: 6
Do NOT do these things: 7

Introduction 8
TallTower History 8
Construction and Assembly 8
Required Parts to Erect Tower System 8
Experience Required 8
Tower Lift Crew 8
Tools Required for various tasks 8

Unpack your tower 11
Description of the packaging 11
Tools required to unpack the 34 m TallTower 11
Access and Orientation 12
Unpack Sequence – Very Important! 12

Site Layout 14
Pre-installation Planning 14
Soil Type and Anchors 14
Tip: Cellular Coverage 14
Site Layout Map 14

Tower Assembly 16
Assemble the Baseplate 16
Install the Anchors 19
Tube Layout 19
SI Units 19
Imperial Units 19
Install the Base Tube 20
Attach sensors and booms 21
Spiral wrap your sensor cables 21

Attach the Guy Wires 22
Organize and layout the lifters and guy wires 22
Shackle guy wires to the guy rings 22
Roll out each guy wire from the tower to its anchor point 22
Secure guy wires to the anchors 24
Shackle lifter wires to the guy rings 24

Assemble the Gin Pole 25
Layout the ginpole tubes 25
Attach the ginpole base tube to the baseplate 25
Slide together the 4 tubes that comprise the ginpole 25
Attach the ginpole top mounting hardware 26
Attach the lifter wires 28
Configure the helper ginpole 28

Ginpole Tilt-Up 30
Confirm all lifters and shackles are secure 30
Lift the ginpole 30

Tower Tilt-Up 31
Understanding Guy Wire Tensioning While Raising TallTower (Do not raise the tower yet) 31
Adjusting Guy Wires (the “Inchworm” method) 31
Loosening Guy Wires 31
Tightening Guy Wires 33
Lift the Tower 34
Transfer Lifters 35
Plumb and Straighten 36
Final Inspection and Maintenance 37

Tower Lowering 38

Appendix A: 34 m TallTower Dimensions 40
Tower Layout 40
Site Layout 41
Baseplate Geometry 43

Appendix B: Anchoring Guidelines 45
Determine site soil and anchor type before you order your tower 45
Anchor Choices and other considerations 45
Screw-In Anchor description 45
Arrowhead Anchor description 47
Rock Anchor description 48
Concrete Anchor description 48
Installing Screw-In Anchors 49
Installing Arrowhead Anchors 49
Installing Rock Anchors 50

Appendix C: Site Visit Procedures 51
Site Checklist 51

Appendix D: Glossary 52

Appendix E: Aligning Wind Vanes 59
Introduction 59
Magnetic Declination 59
Mounting and Aligning Wind Vanes 59
Using Data Analysis Software to Correct for Magnetic Declination 62

Appendix F: Hankmaster Tool for Unrolling Guy Wires 63

Index 65

WARNINGS

Do these things:

Read and follow the Tower Installation Manual!

Determine the soil type at your site and install the correct anchors.

Place tower anchors according to anchor manufacturer's recommendations.

Properly ground the tower electrically.

Stand to the side of any tensioned cables.

Thoroughly understand tower erection procedure before beginning installation. All crew members should read the manual before arriving at the installation site!

Review glossary so that you are familiar with all tower parts and terminology.

If you are NOT familiar with erecting towers of this type, seek professional guidance. We will gladly help answer any questions.

If you have never installed a TallTower before, seek the assistance of a qualified installer.

If you are not thoroughly familiar with all components of the tower, including all hardware and how all components function, DO NOT attempt to install this tower yourself. Tall guyed towers are dangerous, and you or members of your crew can be injured or killed.

If installing the TallTower in an agricultural area, notify appropriate parties and install warning devices as needed. Towers can pose a threat to low-flying crop dusting aircraft.

If you are unsure of how to anchor your tower, seek professional guidance.

Do NOT do these things:

DO NOT climb this tower.

DO NOT erect tower within 1 ½ times the tower height of electric power lines.

DO NOT install this tower during an electrical storm.

DO NOT erect tower within 1 ½ times the tower height of walkways, roads, or buildings.

DO NOT permit unauthorized personnel onto the site while the tower is being installed.

DO NOT raise or lower the tower on a day with high winds or gusty winds.

DO NOT use mechanical tensioning devices to adjust guy wires.

DO NOT use rebar anchors.

DO NOT stand in line with, directly in front of, or behind any tensioned cable.

Introduction

TallTower History

NRG TallTowers™, the original tilt-up tubular towers, were first introduced in 1982 and soon became the industry standard to quickly and easily get sensors up and into the wind to start measurements. TallTowers are delivered in complete kits, assembled on the ground and then tilted up and secured with guy wires.

Construction and Assembly

The NRG TallTower™ is of galvanized steel tube construction and is guyed at four levels in four directions. Sections slide together without the use of bolts or clamps. The tower is tilted up from the ground with a gin pole and winch (winch is not included). Lifting of the tower is done by one set of guy wires (lifting wires) attached to the gin pole. The tower is stabilized sideways with two side guy wire sets. The base plate is hinged so both the tower and gin pole can pivot to the erected position.

Required Parts to Erect Tower System

NRG 34 meter TallTowers are supplied complete with ready to assemble tubes, baseplate, guy rings, precut guy wires, screw-in anchors, grounding kit, and associated hardware. Screw-in earth anchors are included and are suitable for many soil types. Other anchor types are available. It is your responsibility to determine which type of anchor is appropriate for your specific site.

Please refer to the anchoring guidelines in Appendix B of this manual for more information.

A winch and ginpole (ginpole is included with the purchase of this tower) are also required to raise the tower.

The ginpole for the 34m TallTower is NOT compatible with other NRG TallTowers. The ginpoles from other NRG TallTowers are not compatible with the 34 m tower.

Please see the Glossary for pictures and descriptions of tower parts, hardware, and accessories.

Experience Required

If you have no prior experience with TallTower installation, seek assistance from a qualified installer.

Tower Lift Crew

We suggest the following organization to form an efficient and safe crew to erect NRG TallTowers. Each member of the lift crew should have a good understanding of the tasks they are required to perform during the lift.

Five Member Crew:

Crew leader: This person will operate the winch and coordinate the other members. It is especially important to maintain clear communication among the members of the crew. The tower footprint is large and walkie-talkie radios are highly recommended.

Side guy wire tenders: These two people will attend to each side guy anchor and adjust side guy wires. They must be familiar with taking in and letting out guy wires. See the pictures describing the “inchworm” technique for safely adjusting guy wires.

Observers: Two people to assist adjusting side guys, tending the back guy wires at the end of the lift, and otherwise observing guy wires.

Tools Required for various tasks

- ¼ inch nut driver (for sensor installation)
- 5/16 inch nut driver (for hose clamps)
- 7/16 inch (11 mm) socket wrenches (for wire rope clips) – one per crew member
- Large adjustable wrench (for large bolts)
- 1/2 inch wrench, socket or open (for base plate assembly and unpacking
- Piece of rebar or similar (for turning anchors)

- Hand sledge (for ground rods)
- Small adjustable wrench (for opening/closing acorn clamps)
- Small pliers (for sensor cotter pins)
- Small Phillips head (+) screwdriver (for set screws)
- Flat (-) screwdriver (for antenna mounting assembly)
- Knives (to cut electrical tape) – one per crew member
- Level, preferably with a magnetic base (to straighten the tower)
- Compass (for aligning direction sensors)
- Permanent marker (for labeling lower ends of cables)
- (2) 12 V deep cycle marine battery (for electric winch)
- Hankmaster 5000™ guy wire tool (optional)
- Gloves
- 2-way radios or walkie talkies
- Electric drill with 5/16 inch bit (for unpacking and attaching top tube)
- Band cutters (for unpacking)
- 2.5 m (8 feet) stepladder (for reaching end of ginpole on sloped sites)
- Rebar, rock bolts, or steel cable to secure tower base
- 8 wood posts (10 cm x 10 cm x 1 m / 4 in. x 4 in. x 3 ft.) to support tower
- Sawhorse to support ginpole
- Wire cutters

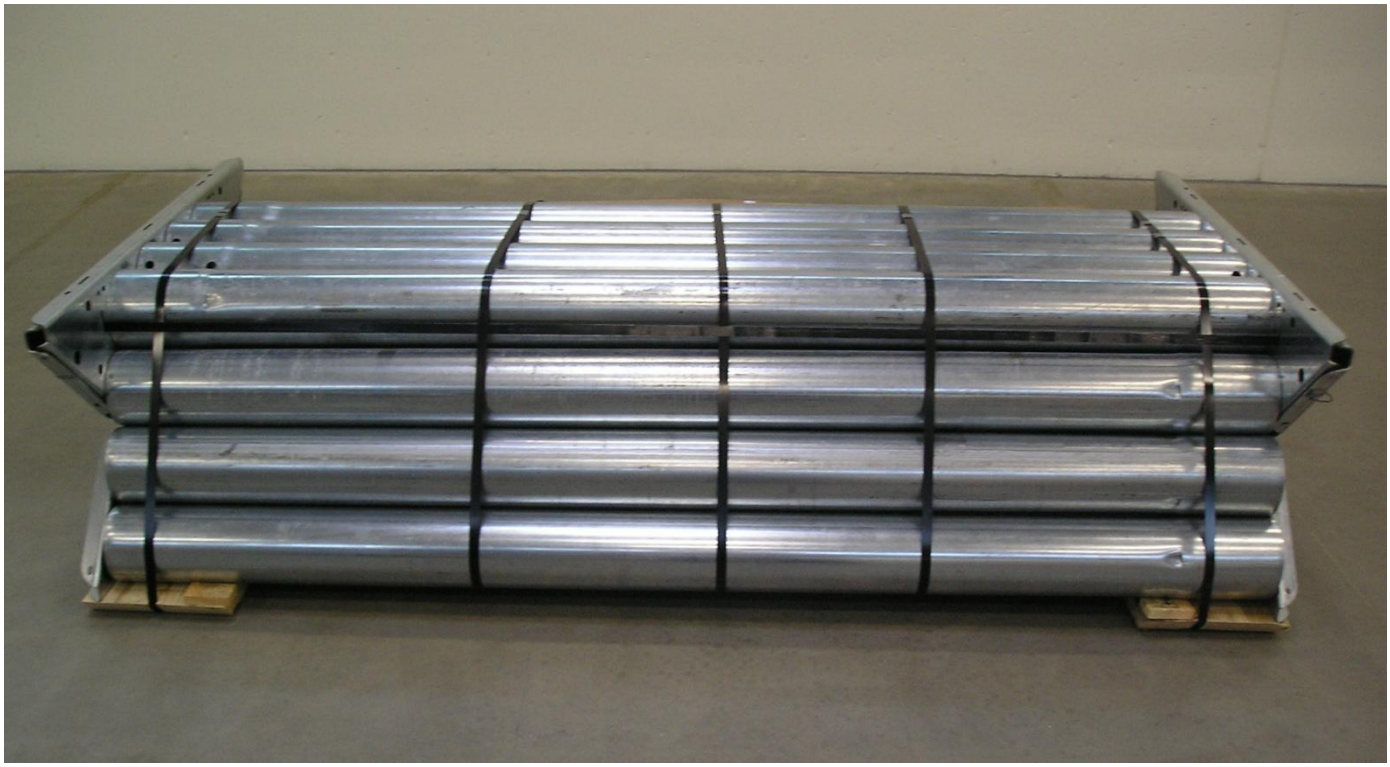
Unpack your tower

Description of the packaging

The 34 m TallTower packaging was designed to reduce cardboard waste, protect the tower components and allow for more economical shipment. All the tower components including anchors and ground kit are now included in one package. If you purchased this tower as part of an NRG-NOW System, the electronics, sensors and associated accessories are packaged separately.

It is very important that you understand how to unpack the contents of the packaging safely. The recommended sequence to unpack the tower is described in this section of the manual.

The tubes may shift position suddenly when bands are cut, so please read this section carefully to avoid serious injury.



Tools required to unpack the 34 m TallTower

- 5/16 inch nut driver or electric drill with 5/16 inch bit
- 1/2 inch wrench for bolts
- Band cutters
- Gloves

Access and Orientation

Ideally, you will want access to both ends of the packaging to unpack the contents. If a forklift is available, that is also ideal. Remove the 34 m TallTower package from the truck with the forklift and set it on an unobstructed flat area before unpacking.

It is also possible to unpack the contents with access to only one end of the tower packaging. For example, the 34 m TallTower may have been placed into a truck with one end against the front wall of the truck's cargo area and no forklift available to remove it from the truck. In this case, you will be able to follow instructions in this section of the manual to unpack the contents and unload from the truck by hand.

Note: You will NOT be able to unpack the contents if the tower package has been loaded into a truck sideways. If it has been loaded into a truck sideways, you will not have required access to the ends and will need a forklift to remove the tower package.

Unpack Sequence – Very Important!

Once you are ready to unpack the contents, follow these steps. With the banding cutters, cut the single horizontal band (#4) and discard.

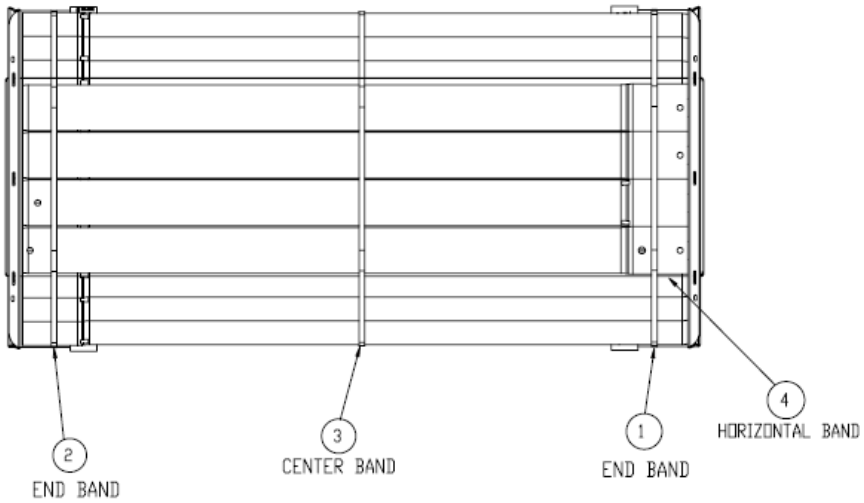
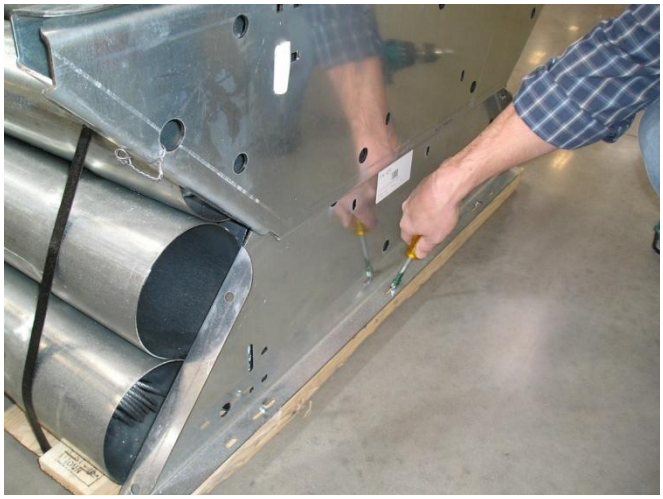


Figure 1

With the nut driver (or powered screwdriver), remove the 4 wood screws that fasten each end plate assembly down to the wood pallet. Set aside the 2 end plate assemblies. If you can only remove one end plate assembly, that is OK. Remove the end plate and set aside.



The tube contents will now be exposed. Beginning at the top, remove the contents of the tubes. These contents will include: screw-in anchors, coils of cable, ground rods, guy rings, rocker plates, and the hardware kits.

At this point, there should only be 152 mm (6 inch) diameter tubes remaining on the pallet. With the band cutters, cut the outer bands (#2 & #1) and center band (#3) as shown. Remove tubes.

Site Layout

Pre-installation Planning

It is a good idea to visit the site before you order your wind measurement system. You will need to make arrangements regarding how to unload your tower system. Some site preparation may also be necessary.

During the first lift of a tower, the many slip joints will settle to the full engagement. During this settling, the distances from the base to any given point on the tower will shorten, and the individual tubes may rotate. Therefore, it is recommended that the tower be "pre-lifted" before the sensors are permanently attached. The "pre-lift" can be only a few feet, but the entire tower should leave the ground. Doing this also is a good way to avoid endangering the booms, sensors, and cabling should there be an unforeseen problem.

Soil Type and Anchors

Before ordering your tower, research the site soil and anchor type required. It is your responsibility to determine which type of anchor is appropriate for your specific site. Depending on the soil type, anchoring can take varying levels of planning, effort and time. Be sure to know what soil types you are dealing with as part of your pre-installation planning process.

Note: (5) 6 inch diameter screw anchors are included with the tower. Other anchor types must be ordered separately. Please refer to the anchoring guidelines in Appendix B of this manual for more information.

Tip: Cellular Coverage

This is also a good opportunity to identify what type of cellular service is available at the site for those who will be using an NRG iPack to transmit data. Contact us for more information on NRG iPacks.

Site Layout Map

Lay out locations for the tower baseplate, guy anchors and the winch anchor. Lay out the site so that the tower is laid out downwind of the baseplate so that the tower will be lifted into the wind. If the site is on a steep slope, lay out the site so that the tower is laid out uphill of the baseplate. Unless the slope is steep, it is more important to have the tower lifted into the wind.

Measure carefully to place the anchor points, paying extra attention to the placement of the winch anchors. Verify that the anchor radii and the diagonal distances between anchors are correct.

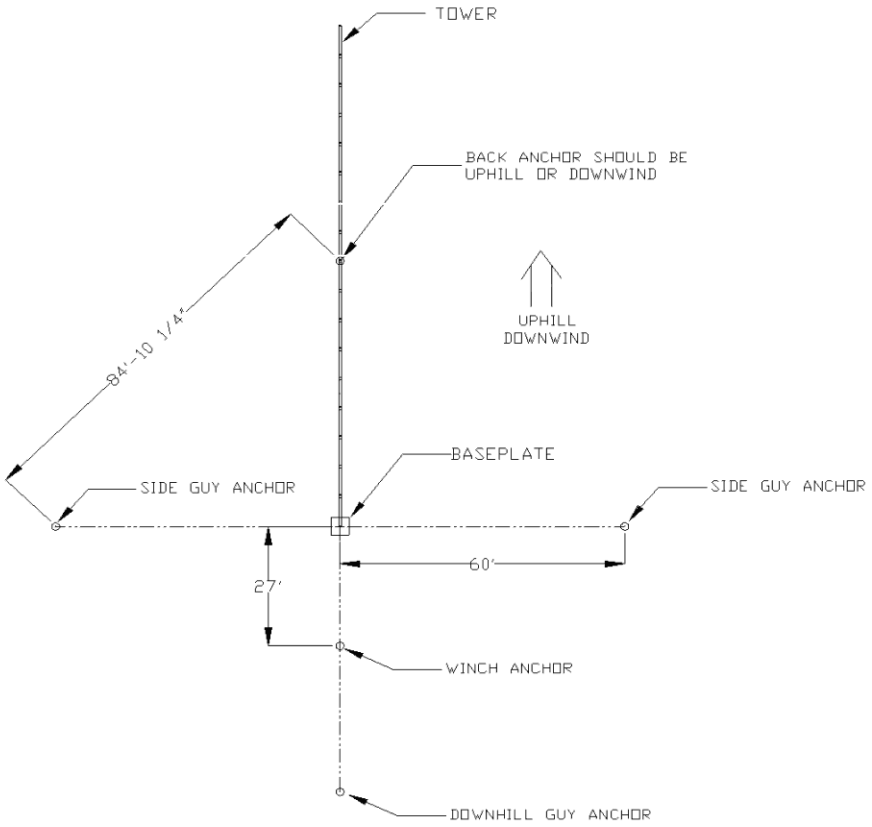


Figure 3: Site Layout Map (bird's eye view)

NOTE: TallTowers can be installed on slopes up to 10°. When laying out a TallTower installation on a slope, measure the calculated distances along the ground to place the anchors. It is not necessary to compensate for the slope. TallTower guy wires are cut long enough to allow for installation on slopes up to 10° while maintaining the ideal angle between the tower and the guys.

NOTE: The side guy anchors and the base plate should be on a straight line. If it is not possible to place them in the locations shown, it is better to move them in or out along the line to the baseplate than to move them off the line. Do not move them more than 1 m (3 feet) off the line, although some sites may require a compromise because anchors may not be able to be located at the preferred spot.

NOTE: Extra care will have to be taken while raising the tower if:

- anchor placement is not perpendicular to the tower as it lays on the ground.
- anchors are not at the same elevation.
- side anchors and base plate are not in a straight line.

NOTE: Any of these conditions will affect the side guy wire tension as the tower is raised. Tension will have to be adjusted periodically as the tower is lifted.

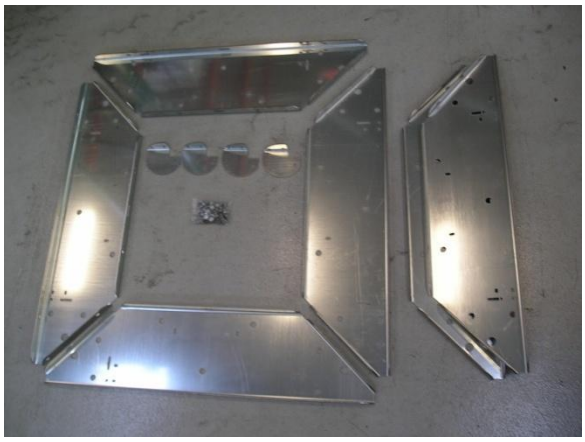
Placement of the winch anchor is critical. Make sure that you measure carefully and set the anchor heads close to ground level. Angle all the anchors toward the tower at 45 degrees.

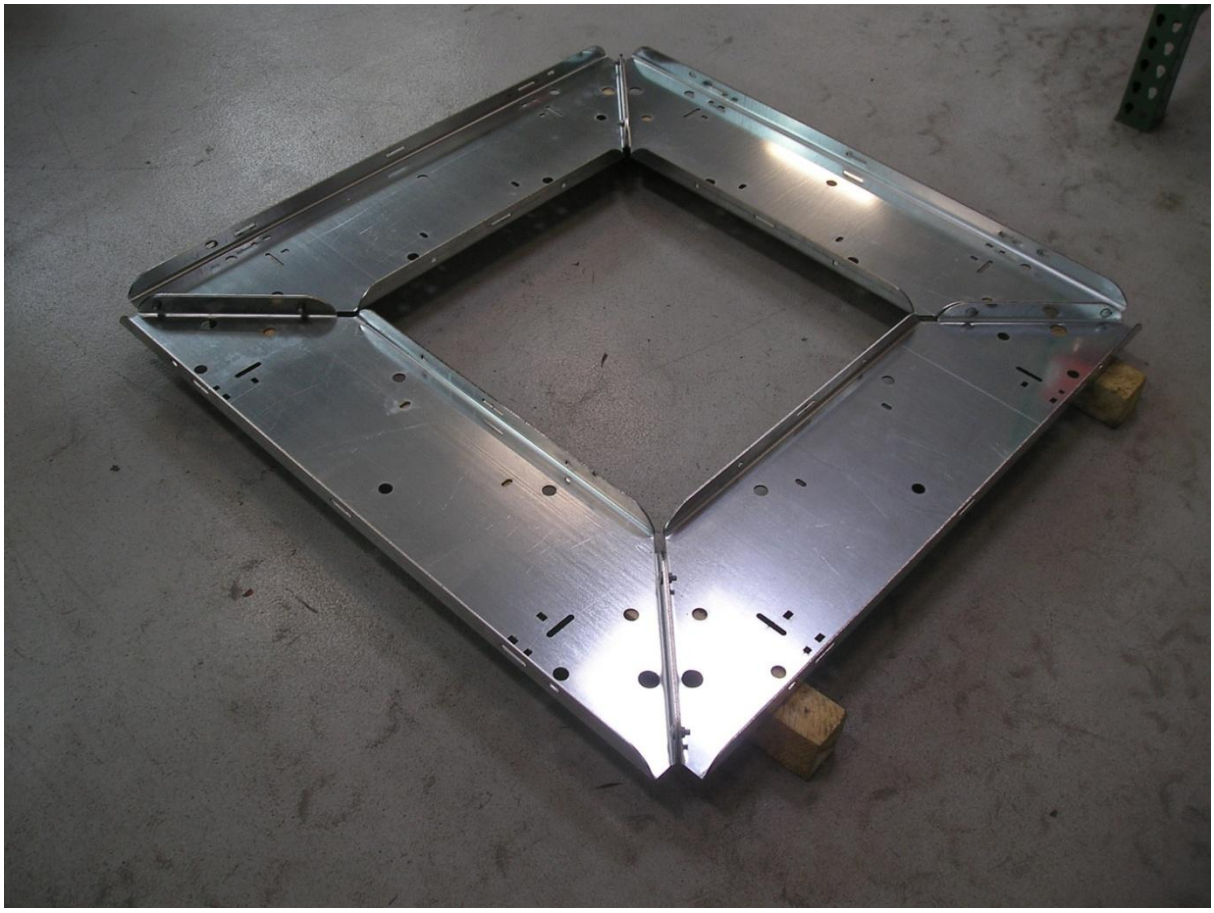
All this is important for proper distribution of forces and for clearance and proper operation of the ginpole. See *Site Layout Map* and *Anchor the Winch* for more information.

Tower Assembly

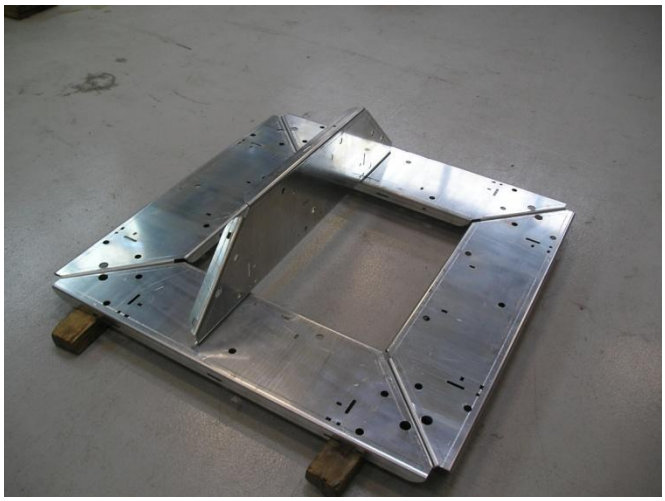
Assemble the Baseplate

The baseplate will be located according to the site layout map described in the previous section. It is often easiest to assemble the baseplate in this location. Assemble 4 of the 6 large triangular baseplate sections as shown below, inserting (8) 5/16" x 3/4" carriage bolts in holes closest to the center of each triangular baseplate section. Leave nuts somewhat loose; tighten by hand only.

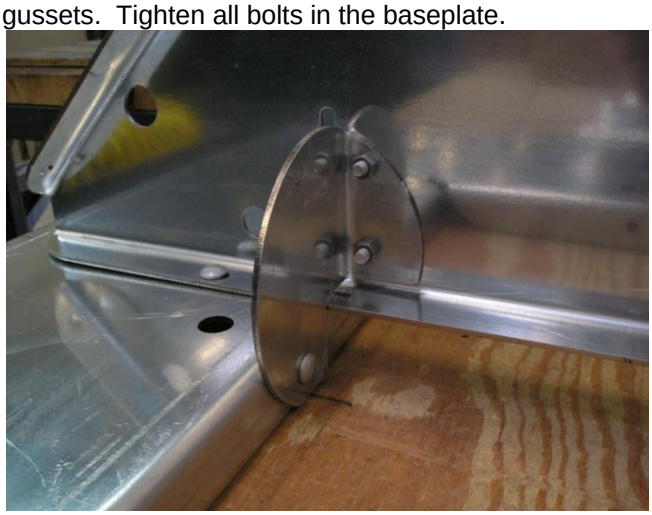




Flip over the baseplate assembly, and prop up on one edge with a block of wood to allow access to underside of baseplate. Attach vertical pieces to the center of the baseplate as shown below, with bent edges facing outward.



Install the gussets (4) as shown below. Be sure to install the gusset bolts with the carriage bolt head away from the gussets. Tighten all bolts in the baseplate.



At the beginning of a lift, particularly for the gin pole, the winch forces are largely horizontal. These forces tend to slide the baseplate toward the winch and/or tip the baseplate up on edge. To counteract these forces, it is highly recommended that the baseplate be anchored against sliding and tipping. There are several possible techniques depending on the terrain, soil, and subsequent operations under the tower.

Rods driven through the baseplate into the soil – With *firm*, deep soil, drive several pieces of rebar through the holes in baseplate into the soil. Angle them away from the winch and place as many as practical along the baseplate front edge (farthest from the winch).

Rock anchors to the baseplate – On rock, or shallow soils, attach rock anchors to the baseplate, particularly along the front edge. These should be positioned and attached to hold the edge of the baseplate down as well as keep it from sliding.

Cable to the Guy Anchor – A cable made up as a bridle connected to the tower bolt can be run to the inner anchor opposite the winch or to an anchor nearer the baseplate. See below for details.

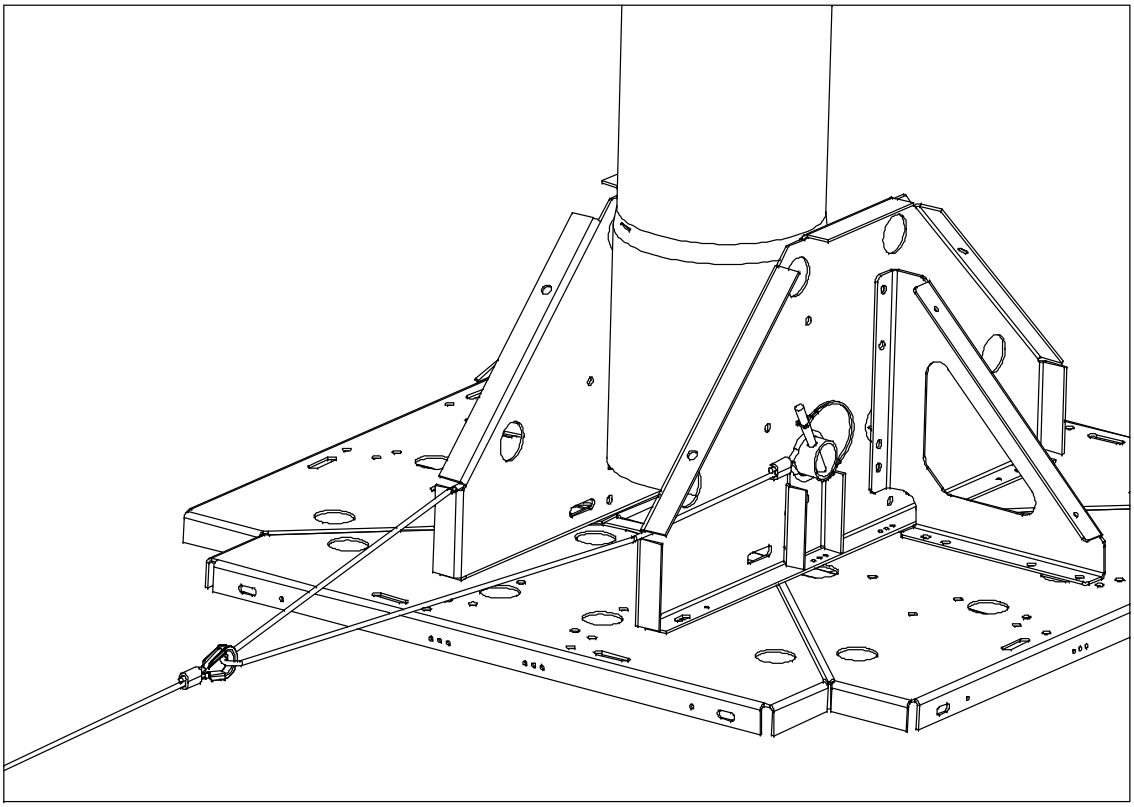


Figure 4

Drive ground rods through the baseplate holes so they can provide additional anchoring for the baseplate.

Install the Anchors

See Appendix B: Anchoring Guidelines at the end of this manual for more information on installing anchors. Depending on the soil type, anchoring can take varying levels of planning, effort and time. Be sure to know what soil types you are dealing with as part of your pre-installation planning process.

Leave the eye of screw-in anchors about 150 mm (6 inches) above ground.

Tube Layout

Lay out the disassembled tube sections on the ground according to sequence described, beginning at the baseplate. Pay close attention to the location of the guy rings.

SI Units

Sequence of tubes in each section A guy ring is placed over the last tube listed in each section.			
Section 1	Section 2	Section 3	Section 4
Base Tube + (4) 2.2 m, 152 mm dia. tubes	(4) 2.2 m, 152 mm dia. tubes	(4) 2.2 m, 152 mm dia.	(4) 2.2 m, 152 mm dia. tubes
Lifters attached to this guy ring are color coded: Red	Lifters attached to this guy ring are color coded: White	Lifters attached to this guy ring are color coded: Black	Lifters attached to this guy ring are color coded: Yellow

Table 1

Imperial Units

Sequence of tubes in each section A guy ring is placed over the last tube listed in each section.			
Section 1	Section 2	Section 3	Section 4
Base Tube + (4) 87 inch, 6 inch dia. tubes	(4) 87 inch, 6 inch dia. tubes	(4) 87 inch, 6 inch dia. tubes	(4) 87 inch, 6 inch dia. tubes
Lifters attached to this guy ring are color coded: Red	Lifters attached to this guy ring are color coded: White	Lifters attached to this guy ring are color coded: Black	Lifters attached to this guy ring are color coded: Yellow

Table 2

Install the Base Tube

Identify the base tube. The base tube has a hole drilled through the flared (wider) end. Attach the base tube to the baseplate using the ¾" x 8" bolt through the lower holes in the center of the baseplate sides. Secure the bolt with the provided nut.

Slide tube sections together until the end of the interior tube is inserted all the way into the outer tube's flare. The inner tube will be stopped. Aligning the weld seams (visible in interior of tube) of each tower section will make it easier to slide the sections together. Continue to assemble the tubes and place guy rings over the tubes according to the sequence above. Make sure the guy ring is placed so the guy ring corners are bent towards the baseplate, and the guy ring corners are in line with each anchor point. Place wood blocks every 5 to 6 meters (15 – 20 feet) to support the tower above the ground, keeping the tower as straight as possible.

Note: Do not use oil on tower joints. This can cause tower failure if the tubes self-flare.

Attach sensors and booms

Assemble the sensors, sensor boots and sensor signal cables to the booms. Wrap the sensor signal cables to the boom as shown below. Secure with weather rated electrical tape such as Scotch Super 88. Secure the booms to the tower with the supplied hose clamps.

If you purchased the sensors and booms as part of a NRG-NOW System, cabling was supplied for (1) 34 m level direction vane, (2) 34 m level anemometers, and (1) 20 m level anemometer. It is always easiest to run the cables from the sensor and booms down the tower. Refer to Appendix E for wind vane alignment tips.

Spiral wrap your sensor cables

Spiral wrap sensor cables around the tower, one wrap per tube joint. The spiral promotes vortex shedding and reduces natural frequency oscillations of the tower. Use electrical tape to tape the sensor cables and ground cables to the tower every few meters. Also tape cables to the tower above and below each guy ring. Where the cables cross each guy ring, protect the cables by wrapping them with a thick layer of electrical tape as shown below.

Attach the Guy Wires

Organize and layout the lifters and guy wires

Sort out and identify the guy wires and place three sets at each guy ring level. These guy wires are all the same length and are interchangeable. Sort out and identify each lifter wire. The lifter wires are NOT interchangeable. The lifter wires are color coded and are assigned to the guy ring shown in the table below. You will have 12 guy wires and 4 lifter wires. All wires MUST be placed correctly.

Highest level = 4 (yellow)

Guy Ring Level	Length	Lifter Color
1	10.5 m (34.56 feet)	Red
2	16.9 m (55.45 feet)	White
3	24.3 m (79.69 feet)	Black
4	31.98 m (104.94 feet)	Yellow

Table 3

Identify the lifter wire for each level. It is recommended that back guy wires (the guy wires opposite the winch) are attached to their guy rings, rolled out, and secured to their anchors first, followed by the side guy wires to eliminate crossing.

Shackle guy wires to the guy rings

Secure the back guy wires first to their corresponding guy rings using the shackles. Attach the guy wires to the guy ring holes under the tower tube. Roll out the back guy wires to their anchor points and secure as described below. Next secure the side guy wires to their corresponding guy rings using the shackles. These guy wires will attach to the side guy ring holes. Roll the side guy wires out to their anchor points and secure as described below.

Roll out each guy wire from the tower to its anchor point

Roll out side and back guy wires from their guy rings to their anchor points. Do not allow twists or kinks in the guy wires. The guy wire and lifter coils can be uncoiled in a hand over hand method while walking out towards each anchor or unrolled using a “Hankmaster 5000” tool (see Appendix F).

CORRECT

Do **not** un-spool cable off the side of the coil as shown below.

NO!

The Hankmaster can be used to roll the guy wires out to the anchors. See Appendix F for instructions for building and using a Hankmaster.

Pass the split rings through the eye of each shackle bolt to keep the shackle pins from loosening.

Secure guy wires to the anchors

Secure guy wires to the back and side anchors by threading the cable through the anchor loop and clamping the cable onto itself using 3 wire rope clips. For the back guy wires it is recommended that the distance to the side guys for each corresponding level be used as a reference distance for attaching to the back anchors. Place the wire rope clip on the wire so the saddle (the forged, grooved part) cradles the wire coming from the tower and the “U” bolt part clamps down on the dead end of the guy wire (“Never saddle a dead horse” may help you to remember how to secure the wire rope clips).

Leave a little slack in the guy wire, and tighten the wire rope clip nuts. Don’t tighten the wire rope clip nuts too tightly; you will need to adjust the guy length numerous times as the tower is erected.

Shackle lifter wires to the guy rings

Secure the lifter wires to the guy ring holes on the top of the tower tube. Carefully lay out the lifters in an orderly fashion. The unattached ends can easily become entangled around each other and the other guy wires lying on the ground. Make sure that all back and side guy wires are underneath the lifter guy wires. Keeping the lifter wires organized will avoid having to stop during the lift process to untangle the lifters.

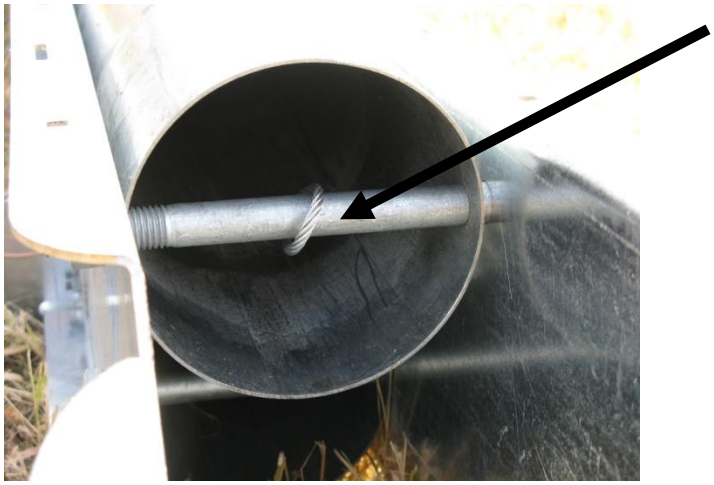
Assemble the Gin Pole

Layout the ginpole tubes

Identify the ginpole and helper ginpole tubes and hardware. Refer to the Glossary in Appendix D for pictures and descriptions of ginpole parts.

Attach the ginpole base tube to the baseplate

The ginpole base tube will lie on top of the tower base tube. Place the ginpole base tube with hole between the baseplate's vertical channels. Insert the safety cable into the ginpole base tube. Line up the holes in the ginpole base tube with the holes in the baseplate's vertical channels and insert the ¾" x 8" bolt through the baseplate holes and the eye in the safety cable. Secure the bolt with the provided nut.



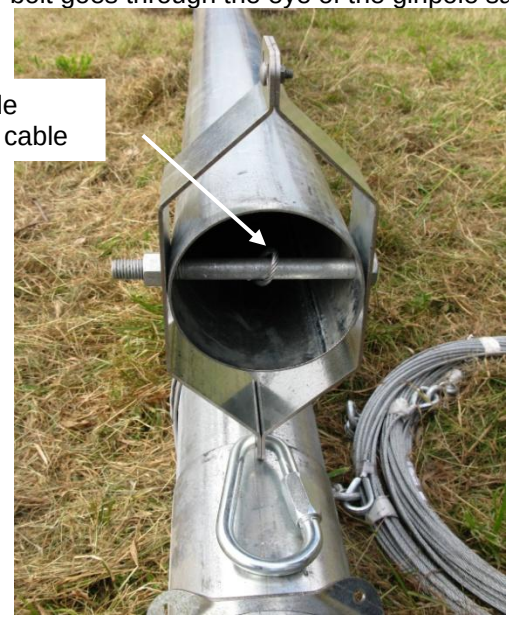
Slide together the 4 tubes that comprise the ginpole

Slide sections together until a hard stop is reached, and thread the safety cable through each tube as it is assembled. Aligning the weld seams (visible on interior of tubes) of each tower section will make it easier to slide the sections together. Place a log, sawhorse, or other type of support underneath the 3rd or 4th section to slightly raise the ginpole from the tower.

Slide the top ginpole section on so that the holes in the ginpole top are parallel to the ground.

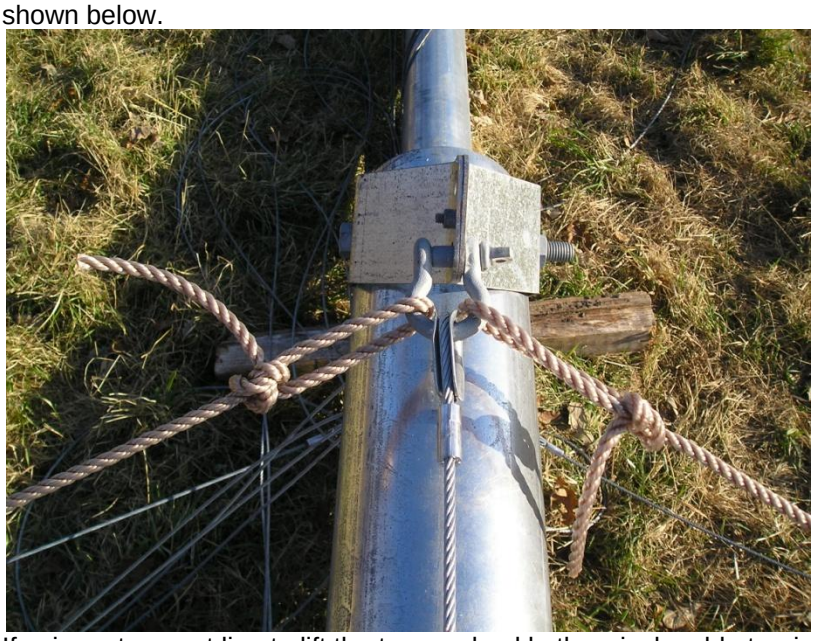
Attach the ginpole top mounting hardware

Bolt the rocker plates to the top section of the ginpole with the large bolt (3/4 inch x 8 inches), making sure that the bolt goes through the eye of the ginpole safety cable.



Also place the (2) supplied graded 5/16“x 3/4“ bolts at the ends of the rocker plates. Attach the (2) quick links to the holes on the bottom (side towards tower) of the rocker plate.

Using a two-part line to lift the tower is optional. If lifting the tower with a single part line, the turning block and one of the shackles are not needed. Simply attach the thimble end of the winch cable to the shackle on the rocker plate as shown below.



If using a two-part line to lift the tower, shackle the winch cable turning block (not supplied) to the rocker plates using the (2) shackles (not supplied) placed through the rocker plate hole shown in the picture below.

Your tower was supplied with a 45.7 m length of 12 mm (1/2 inch) diameter brown polypropylene rope. Cut the rope in half to make two 22 m (75 ft.) pieces. Tie one piece from each side anchor to the top of the ginpole to stabilize the ginpole while it is being raised.

Warning: Failure to use the ginpole ropes could cause the ginpole to fall over to either side during the lift. Be sure to tie the safety ropes securely to the side anchors; the ginpole is very heavy, and the safety ropes can't be controlled by hand.

NOTE: The greatest load seen by the end of the ginpole (and the winch) is 907 kg (2000 lbs.). The winch cable must be 6 mm diameter and at least 19 m (60 ft.) long so that it can reach the end of the ginpole. Size your winch and rigging accordingly. An extra anchor has been supplied with the 34m tower to anchor the winch.

Attach the lifter wires

Attach each of the four lifter wires to the ginpole using the supplied quick links. Be sure to connect them in the proper order and make sure they are not tangled with each other or side or back guy wires.

Lifter #	Lifter Color	Quick Link (number indicates hole)
4	Yellow	2 (top - away from base of tower)
3	Black	2
2	White	1
1	Red	1 (bottom – toward base of tower)

Table 4

Configure the helper ginpole

Put the helper ginpole standing vertically (pulleys pointing towards the sky) on the baseplate behind the main ginpole. Line up the holes in the helper ginpole with the holes in the baseplate's vertical channels. Slide the ¾" x 8" bolts through holes to secure in a vertical position. Secure the bolts with the provided nuts. The hardware kit contains two 5" diameter pulleys and an axle bolt to be used on the top of helper ginpole. If you are only using a one part line from the winch, the second pulley is not needed.

Ginpole Tilt-Up

Confirm all lifters and shackles are secure

Carefully double check all connection points to make sure everything is secure before starting to lift the ginpole.

Lift the ginpole

Make sure the ginpole remains centered side to side and that the brown ropes are both snug. If the ginpole is off center, carefully adjust the ropes to re-center. As the ginpole comes up, remove the helper ginpole when the winch cable is no longer in contact with the pulleys on the end of the helper ginpole. Pay attention to the lifters to make sure they are not caught on objects in the area (stumps, debris, rocks, equipment, etc.). Also check that they are not crossed over each other or the other guy wires. As the lifter wires tighten, **stop**.

Do not lift the tower yet. Check that the shackles are not twisted at the guy rings.

Tower Tilt-Up

Understanding Guy Wire Tensioning While Raising TallTower (Do not raise the tower yet)

As a tower is raised, unless the anchors are placed in precisely their correct positions, and unless the site is perfectly level, some guy wires will tighten and some will loosen as the tower is raised. The same is true as a tower is lowered on the same site. For this reason, guy wire tension must be checked and adjusted as needed to maintain uniform tension until the tower installation procedure is complete.

A wire that becomes too tight can put very high forces on both the anchor and the tower. This force can rapidly grow if the tower lifting or lowering procedure continues. These high forces can suddenly buckle the tower and cause it to fall, endangering the tower installation crew and possibly damaging any vehicles or equipment nearby. Do not let the tower be bowed to the side more than two tower diameters away from a straight line. If the tower is bowed more than this, the side guys should be adjusted to straighten the tower.

It is critically important that proper tension be maintained on side guy wires at all times during the lifting procedure to provide side support for the tower. Too little tension can allow the tower to buckle to the side. Too much tension may cause failure of the tower, anchors, or guy wires. There must always be visible slack in the guy wires. If no slack is visible, the tension is too great.

Once the tower is vertical, two people of average size, pulling by hand, can properly tension the guy wires.

MECHANICAL TENSIONING DEVICES SHOULD NEVER BE USED TO ADJUST GUY WIRES!!

Be sure that guy wires do not get caught on tree branches, roots, rocks, or other obstructions.

This sequence of observing, communicating observations, issuing commands to guy wire tenders, adjusting the side guy wires and re-tightening wire rope clips must be well understood before lifting a tower. The sequence will be repeated many times before a tower installation is completed on all but the most flat and level sites.

Adjusting Guy Wires (the "Inchworm" method)

Loosening Guy Wires

As the tower is raised, the side guys may become tight. To adjust the cable, start by making sure the 3 wire rope clips are secure. Tighten using a wrench. Then:

1) Loosen the upper clip and pull a length of the tail through the clip, creating a loop as shown below. Tighten the upper clip to "trap" the loop between the upper clip and the lower clips.

2) Now loosen the lower clips, loosening the lowest clip slowly, allowing the loop to slide, which will slacken the guy wire.

3) Retighten the lowest wire rope clip.

4) Repeat as necessary from step 1 to create the proper cable tension.

Tightening Guy Wires

As with loosening, make sure to start with all 3 wire rope clips secure. Tighten using a wrench as shown below. Then:

1. Loosen the lower 2 wire rope clips as shown below.
2. Pull the 2 cables apart to form a loop (similar to the loop made while loosening), then tighten the lowest rope clip to trap the loop between the upper and lower rope clips as shown below.

3. Loosen the upper rope clip and pull the tail to remove the loop.

4. Finally, tighten the upper clip.

5. Repeat as necessary from step 1 to tighten the cable.

Lift the Tower

When all crew members are ready, the winch operator will begin to lift the tower. Remember that most electric winches are designed for intermittent use, and frequent rests must be taken to prevent the winch motor from overheating. Help the cable to wind evenly by using the winch control handle to move the winch motor from side to side.

Warning: Allowing the cable to wind unevenly will result in crossovers that will damage the cable and fill the winch drum before the tower is fully raised.

Lift the tower about 1 m (3 feet) off the ground while checking side guy tensions. The lifters are set up to produce a slight bow in the tower, with the top 0.15 m to 0.3 m (6" to 1 foot) higher than the middle (we refer to this as a "positive curve"). This is normal, and it needs to be maintained throughout the entire lift to avoid tower buckling or collapse. Adjust the side guy wire tensions to prevent the tower from either falling off to one side or bowing which could damage the tower.

Warning: The tower must remain straight side to side and maintain a positive curve as described above. Failure to maintain the proper shape can cause the tower to collapse, endangering the crew and equipment. This is the highest stress point of the lift.

Watch the winch anchors for movement. The maximum lifting force will be experienced when the tower is first lifted a few feet off the ground. If the winch anchors will not hold, either the anchor was not installed correctly or another type of anchor is needed. See Appendix B: Anchoring Guidelines for more information.

Watch the tower baseplate for movement toward the winch. If either the winch anchors won't hold or the baseplate slips, immediately lower the tower.

If everything looks OK, continue to lift the tower a little at a time, checking side guy tension along the way. At times, it may be necessary to adjust the side guy wire tension. Do this ONLY when the winch is stopped. Readjust with wire rope clips, letting cable out or pulling loose cable in (see "inchworm" technique). Work slowly and smoothly. Fast, uneven movements tend to make the tower bounce, shake or swing. *Be sure that communication between all members of the lifting team is clear and concise.* Continue lifting and adjusting until the tower is about 60 degrees above horizontal (just above half way). **STOP**.

Beyond 60 degrees above horizontal, it is absolutely essential that tension is maintained on the back guy wires during the last part of the lift, particularly the guy wires at levels 2 and 3. Excess tension on level 4 will remove the positive curve shape from the tower and potentially cause a collapse. So don't do it. The tower will lift very easily at this point because the weight of the ginpole and winch will be enough to tip the tower without powering the winch, causing total loss of tower control. Any wind blowing in the direction of the lift will also help reduce the load on the winch. *Therefore, the crew must control the lift from this point on using the back guy wires.*

Before continuing the lift, adjust the back guy wires to take out the excess slack.

Continue the lift by alternately powering the winch and smoothly and incrementally (a few feet of guy wire at a time) letting out on the back guy wires (in order from top to bottom) using the inchworm technique. Do not completely remove slack in back guy wires by running the winch too long. Continue this process until the **top** of the tower is directly over the base (sight with a carpenter's level).

Warning: Avoid winching in too much cable (to the point where the pulley collides with the winch). If the pulley and winch are winched tightly together, the winch cable can break, causing total loss of tower control. Please note that the winch's motor has a slightly delayed response after the switch is released, and while coasting to a stop may produce enough force to break the winch cable.

Re-check that the tension in the back guys and in the side guy wires is set up correctly to about 23 kgf (50 pounds) of tension, allowing some slack in each guy wire. Check that wire rope clips are secure.

Transfer Lifters

Next, you will transfer the lifting guys one at a time from the gin pole to their respective anchors. You will secure each lifter guy wire with wire rope clips. Remember that while the lifter is disconnected, you will be holding the tower! **Maintain tension while transferring the guy wires.**

As mentioned before, it is normal to have the tower bowed slightly away from the winch. As you transfer the lifters, you may have to add a little slack to the middle level back guy wires to allow the tower to straighten.

Transfer the lifters one at a time from the quick links on the ginpole to their anchor. Secure each with wire rope clips. Remember that you will be holding the tower. Maintain tension while transferring the wires. Start with the top lifter level (level 4 yellow). Adjust the guy tension on the lifter and the guy opposite to pull the tower straight and vertical. Working downward, transfer the lower level lifters one at a time to their anchor. Again, check the tension on the lifter and its opposite guy as each is transferred. To keep the tower straight, it may be necessary to winch out slightly and or adjust the opposite guys as the lifters are transferred. As you remove the last lifter, lower the ginpole to the ground.

Plumb and Straighten

Make final adjustments to the guys. Using a carpenter's level on the base tube, adjust the lowest level guy wires as needed so the base tube is vertical. Working upward, adjust all four guys at each level while sighting up the tower from the base to straighten the tower (see picture below).

As you finalize the straightening of the tower, you will need to set the final tension on the guys.

Final Inspection and Maintenance

Tighten all wire rope clips on each guy wire now, with about 100 mm to 200 mm (4 inches to 8 inches) between clips. Re-check that all wire rope clips are tight. Final torque on wire rope clips should be 20 Nm (15 ft-lb) for 1/4 inch wire rope clips. The ginpole may be left in place, or it may be removed and disassembled if desired. If using guy guards, attach one to each guy wire and one to the winch anchor as shown below.

Check the tower in 2 or 3 weeks; tighten loose guys and straighten the tower if needed. It is especially important to do this before any icing events occur. Also check the guy wires after any severe ice or wind storm. Some settling of the tower or anchors may occur, and guy wires can stretch. Loose guy wires can also result when the wire rope clips securing the guys are forced down by the impact of sliding ice.

One of the most important reasons for good tower maintenance, particularly guy tension maintenance, is to avoid a form of tower failure known as “Snap-Through.” Snap-Through typically occurs when the guys are allowed to become loose, and a high wind is blowing on the tower. Even in normal conditions, the upper guys work at a narrower angle to the upper tower than the lower guys, reducing their effectiveness at restraining sideways bending (see figure below). If the guys are allowed to become loose, the working angle is further decreased. If the loads are high enough, or the guys are too loose, the angle between the guy and the tower will reduce to zero, and the guy can no longer restrain the sideways motion. The result is that the upper tower “snaps through” and falls over.

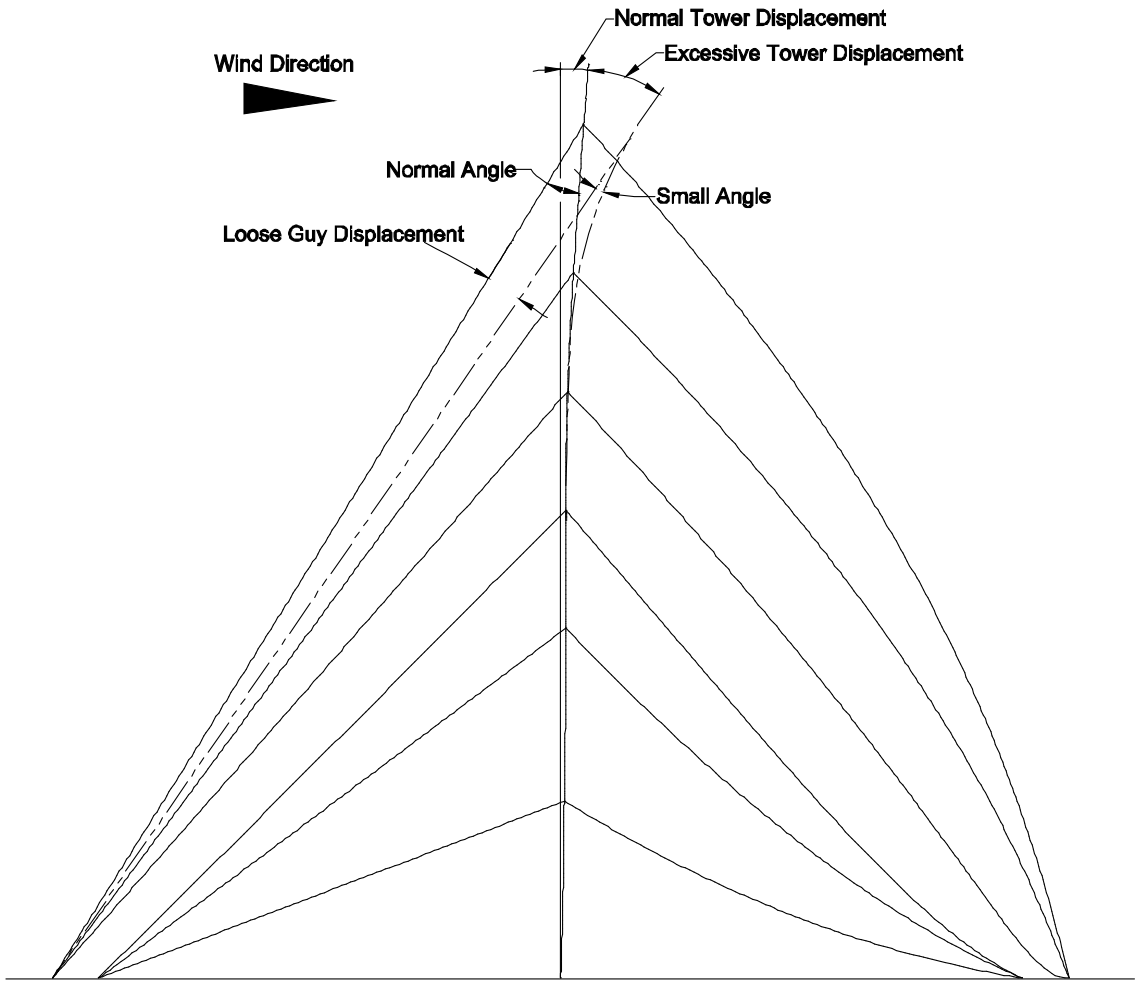


Figure 8

Tower Lowering

Lowering the tower is the reverse of raising the tower, though there are a few additional precautions to be taken. Just as side guy wire tension may vary during the lifting process, the same is true as the tower is lowered. Side guy wires will have to be tended in order to maintain proper guy tension.

If the ginpole was removed, set up the ginpole as described previously. Remember that the extensions of the coupler plate will now be facing the ground. If the tower will be lowered onto blocking, place the blocking now while it is still safe to work under the tower. Lift the ginpole and transfer the lowest level lifting guy wire from the anchor to the ginpole. Remember you will be holding the tower: maintain tension while transferring the wires. Winch in or out as needed to maintain the correct amount of tension in the guy wire when it is transferred. ***The winch cable must always spool and unspool from the bottom of the cable drum in order for the winch brake to work properly.***

Transfer the lifter guy wires from the anchor to the ginpole, in order from lowest to highest. Tension must be applied to the back guys to pull the tower away from the winch as you begin lowering. This keeps wind loads and/or the weight of the ginpole from suddenly pushing the tower back upright, which could cause guy wire or anchor failure. Leave the guy wire attached to the anchor and pull outward on the guy wire to take out the slack. The safest way to do this is by tying a rope around the guy wire. This allows the crew members to maintain tension by hand without being under the tower.

Maintain tension on a minimum of one mid-level and one top level guy wire during lowering. Use two crew members to tend two top level and two mid-level guy wires. These crew members should maintain tension in the back guys and take up the slack in the guy wire as the tower lowers toward them.

As the tower is lowered and reaches an angle of between 75 and 60 degrees, it will no longer be necessary to maintain tension on the back guy wires. Stop the winch at least as often as each 20 degrees to re-check side guy wire tension and to allow the winch to cool for a minute.

Warning:
The force on the winch is greatest as the tower nears the ground. Be sure to stand to either side of the winch cable and behind the winch, batteries, and power cables rather than directly in line with it.

To lower the ginpole, put the helper ginpole in place. As the ginpole nears the ground, place the winch cable (both strands if using a two part line) in the 2 pulleys on the top of the helper ginpole. The pole can then be lowered to the ground.

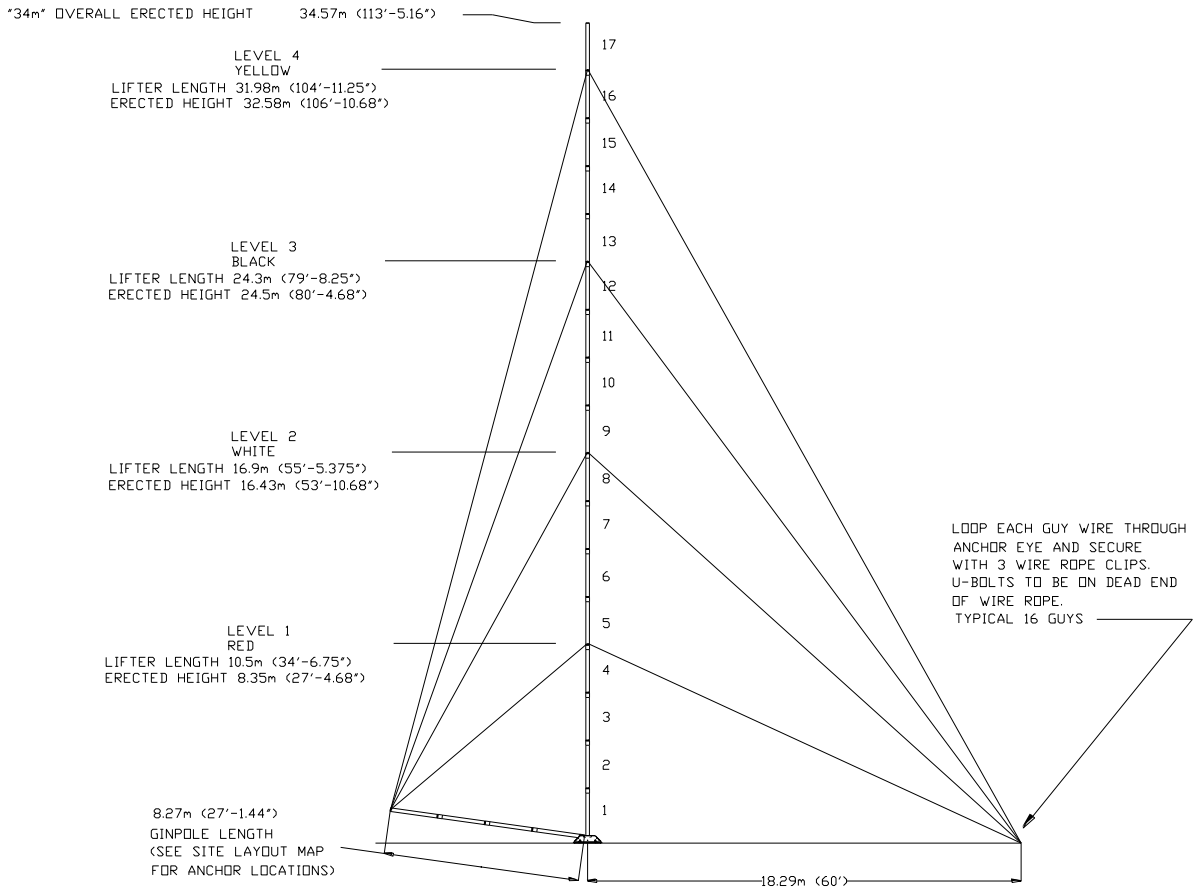
Appendix A: 34 m TallTower Dimensions

Tower Layout

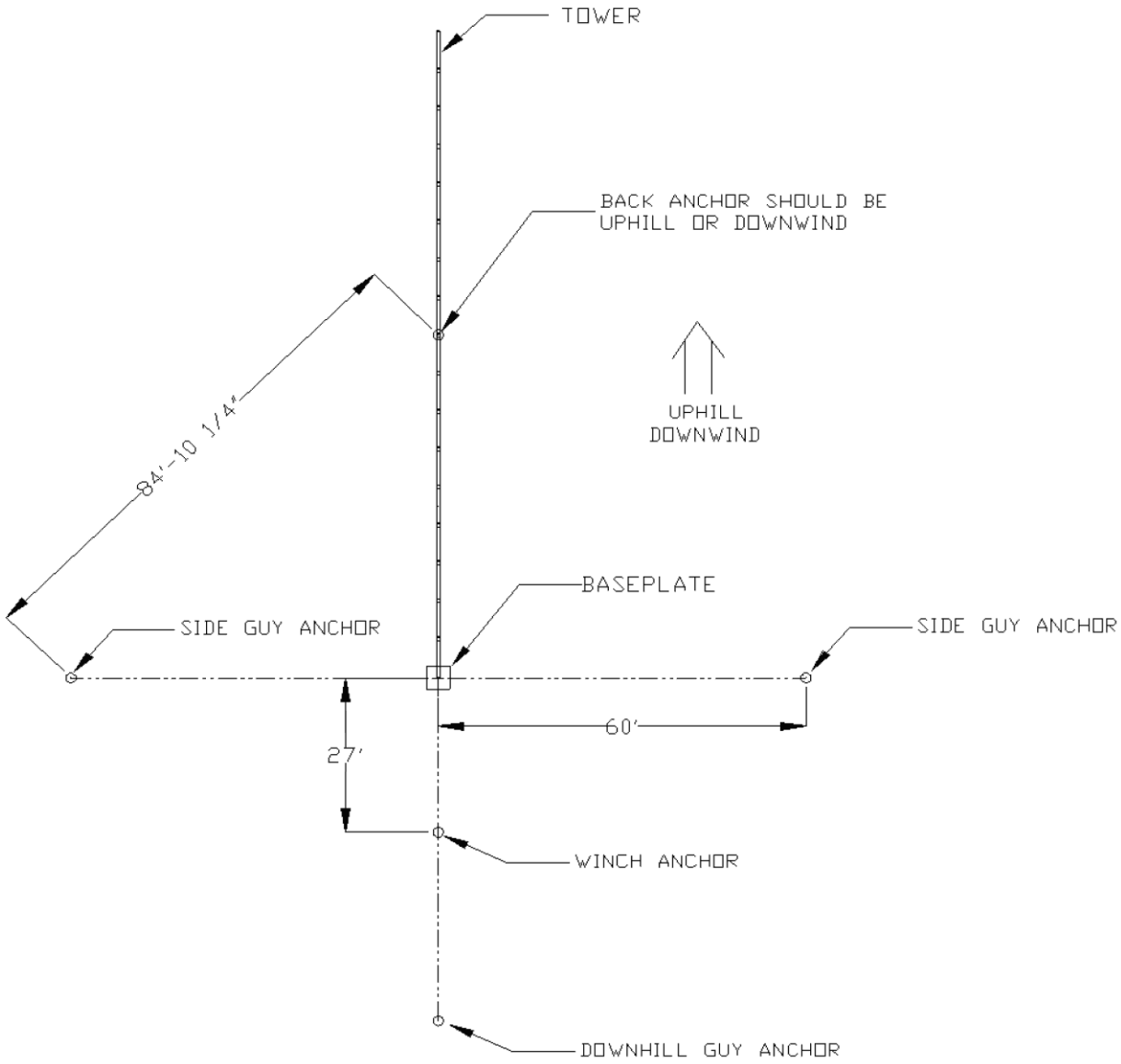
TUBE SPECS (in order of assembly):

Tower:
Base Tube (with pivot pin hole) 6" Ø x 87"L (1 tube)
Plain Tubes 6" Ø x 87"L (16 tubes)

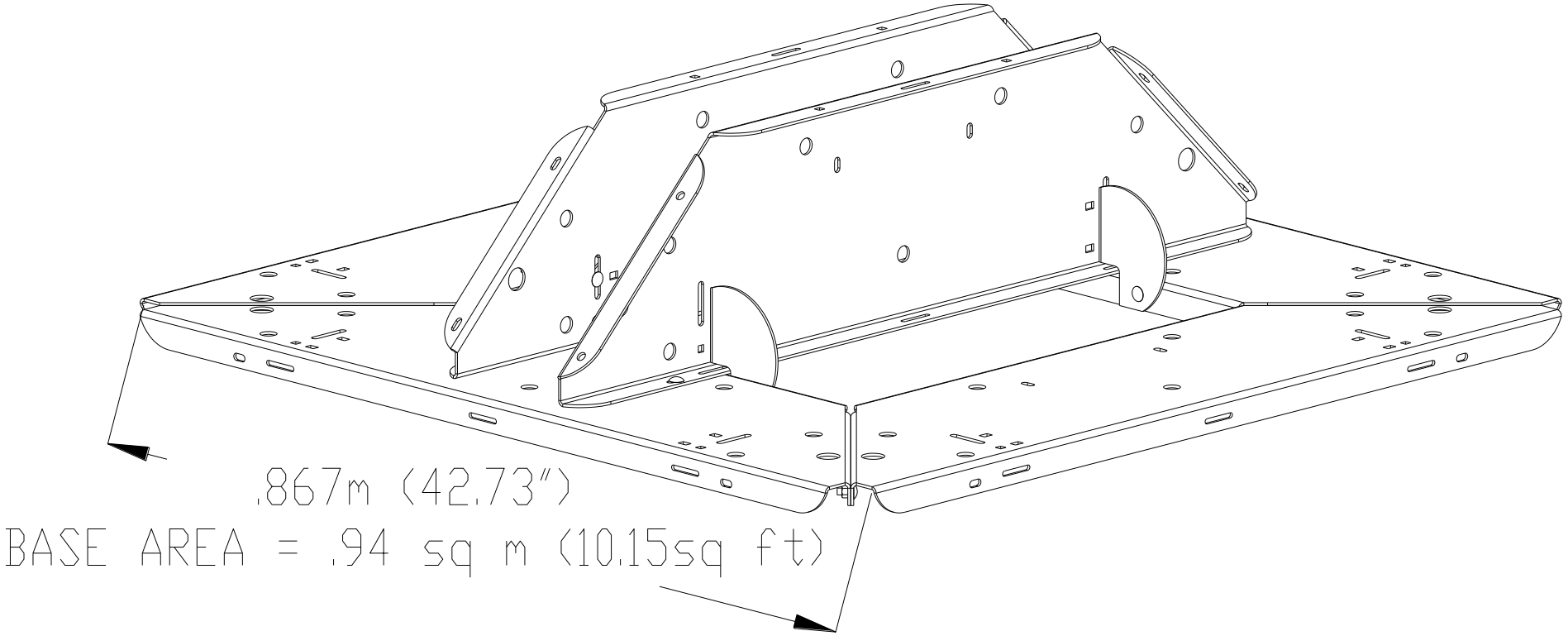
Gin Pole:
Base Tube (with pivot pin hole) 6"Ø x 87"L (1 tube)
Plain Tubes 6"Ø x 87"L (2 tubes)
Top Tube (with rocker pin hole) 6"Ø x 87"L (1 tube)



Site Layout


TOWER
BACK ANCHOR SHOULD BE
UPHILL OR DOWNWIND
UPHILL
DOWNWIND
84'-10 1/4"
BASEPLATE
SIDE GUY ANCHOR
SIDE GUY ANCHOR
60'
27'
WINCH ANCHOR
DOWNHILL GUY ANCHOR

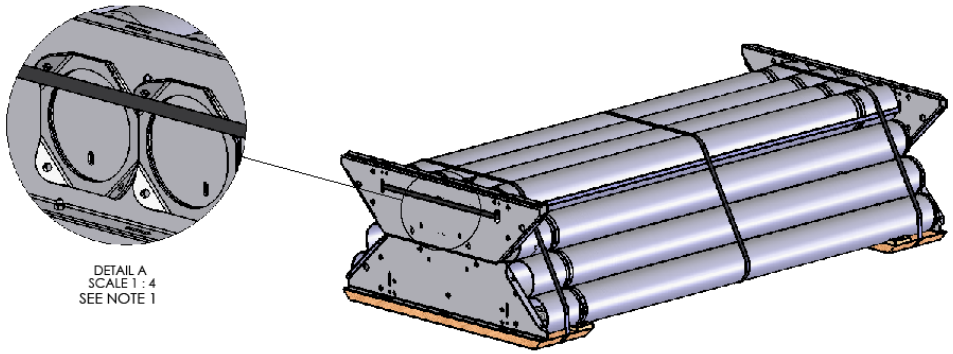
Baseplate Geometry



THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF NRG SYSTEMS. ANY REPRODUCTION IN PART OR WHOLE WITHOUT THE WRITTEN PERMISSION OF NRG SYSTEMS IS PROHIBITED.

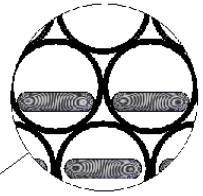
PART # S4253

REV.	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE	11/2/08	EMR
B	ADDED GUY GUARDS	1/18/10	EMR
C	S4461 WAS N4957, N4958, and N4959	1/18/10	EMR

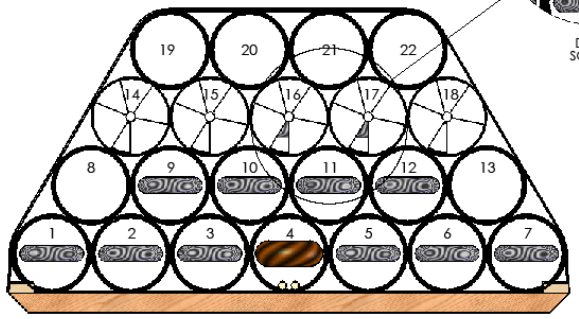


DETAIL A
SCALE 1 : 4
SEE NOTE 1

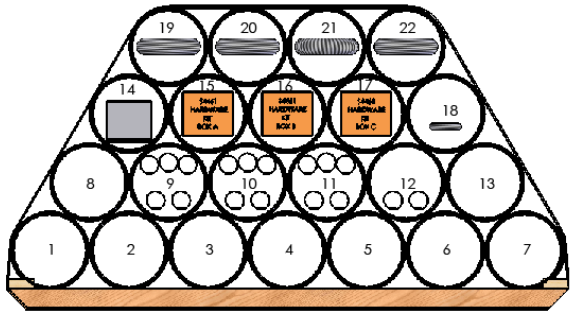
Item	P/N	Description	QTY	LOC
1	S4248	6" Dia. Drilled Base Tube	2	A19,A20
2	S4249	6" Dia. Tube	18	A1-A18
3	S4250	6" Dia. Drilled Ginpole Top Tube	1	A-21
4	S4251	6" Dia. Drilled Ginpole Helper Tube	1	A-22
5	S4243	Universal Guywire Assembly	12	A1-A3, A5-A7, A9-A12, A16, A17
6	S4244	Level 1 Lifter Assembly	1	B19
7	S4245	Level 2 Lifter Assembly	1	B20
8	S4246	Level 3 Lifter Assembly	1	B21
9	S4247	Level 4 Lifter Assembly	1	B22
10	S1604	6" Screw-in Anchor	5	A14-A18
11	S4236	Baseplate	6	BOTH ENDPLATES
12	S4023	Rope 150' Length	1	A4
14	S4240	6" GuyRing	4	"A" SIDE ENPLATE
15	S4241	GinPole Rocker Plate	2	B14
16	S3959	Ground Rod	2	A4
17	N4936	Safety Cable Assembly	1	B18
18	S4447	Guy Guards	17	B9-B12
19	S4461	Hardware Kit Box A	1	B15
20	S4461	Hardware Kit Box B	1	B16
21	S4461	Hardware Kit Box C	1	B17



DETAIL D
SCALE 1 : 5



SIDE A



SIDE B

HARDWARE KIT BOX B

General Table		
P/N	Description	QTY
S1247	3/16" Wire Rope Clips	52
S1277	1/4 - 20 Nut	1
S1330	1/4" Washer	1
S1339	1/4 - 20 Screw	1
S1525	Ground Rod Clamp	2
S1587	5/16" - 18 Nut	26
S4252	5/16" - Carriage Bolt	26
S4261	Ground Lug	1
S4242	Gusset Plates	4
S1601	Quick Link	2

NOTES:
1. BASEPLATE REMOVED IN DETAIL A FOR CLARITY.
2. ANCHORS REMOVED IN DETAIL B FOR CLARITY.

HARDWARE KIT BOX A

P/N	Description	QTY
S3099	CD-ROM	1
S1605	7/16" Nutdriver	1
S1444	Ground Wire 4'-6" Length	2

HARDWARE KIT BOX C

P/N	Description	QTY
S1543	3/4" - 10 Bolt w/ Nut	6
S3908	5" Pulley	2

DO NOT SCALE DRAWING

INTERPRET DWG 3RD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES +/- 1/16 .X +/- .030 +/- 1 .XX +/- .015 .XXX +/- .005

MATERIAL —

FINISH — UNLESS OTHERWISE SPECIFIED

CAD GENERATED DRAWING. DO NOT MANUALLY UPDATE

NRG SYSTEMS

S4253_34m NRG TallTower, Palletized, 6in. Anchors

DRAWN EMR 11/2/08

RESPONSIBLE ENG APPROVAL —

SIZE C

SHEET PART # S4253

REV. C

SCALE —

CAD FILE: S4253_34m NRG TallTower, Palletized, 6in. Anchors

FOLDER: \\Us01engineering\Engineering\Files\NRG Stock\S4253\

SHEET 1 OF 3

Appendix B: Anchoring Guidelines

Determine site soil and anchor type before you order your tower

Before the tower is ordered, the soil type should be determined and the correct anchors ordered. The purpose of this section is to give you the information needed to provide suitable anchoring for your TallTower. **Because anchor requirements are site specific, it is the responsibility of the customer to determine anchor requirements. If you are not sure what is required, seek professional guidance.**

Local utility companies can often provide useful information regarding anchoring used in the site area. Do not use rebar anchors, especially when the surface soils are loose or wet.

Table 6: Soil Classes

Class	Common Soil Types	Geological Soil Classification
3	Dense clays, sands and gravel; hard silts and clays	Glacial till; weathered shales, schist, gneiss and siltstone
4	Medium dense sandy gravel; very stiff to hard silts and clays	Glacial till; hardpan; marls
5	Medium dense coarse sand and sandy gravels; stiff to very stiff silts and clays	Saprolites, residual soils
6	Loose to medium dense fine to coarse sand; firm to stiff clays and silts	Dense hydraulic fill; compacted fill; residual soils
7**	Loose fine sand; Alluvium; loess; soil-firm clays; varied clays; fill	Flood plain soils; lake clays; adobe; gumbo; fill

** In class 7 soils, it is advisable to place anchors deep enough to penetrate underlying class 5 or 6 soil.
Charts reproduced by permission, The A.B. Chance Co.

Anchor Choices and other considerations

The choice of anchors must take into consideration soil type, maximum winds expected, icing or other weather that may affect the tower, and a safety factor suitable for the location and to meet any legal requirements. Considerations include but are not limited to: tornadoes, hurricanes or typhoons, locations where very high winds are expected, potential for flooding or periodic soaking of the soil, soil erosion, and icing events.

Screw-In Anchor description

Screw-in anchors are the most commonly used anchors for normal clay soils without rocks. They are installed by hand, using a cross bar to screw them into the earth like a corkscrew.

Screw-in anchors can also be used to provide the anchoring rod and eye for site-built anchors, such as concrete. Refer to the information on concrete anchors below. 150 mm (6.0 inches) diameter screw-in anchors are the standard anchors supplied with NRG TallTowers. 203 mm (8.0 inches) diameters screw-in anchors are available upon request.

Table 7: Specifications for 152 mm (6 inches) diameter Screw-In Anchors

	150 mm (6 inches) Anchor
Helix diameter:	152 mm (6.0 inches)
Length Overall:	1.65 m (66 inches)
Rod diameter:	19 mm (0.75 inches)
Material:	Galvanized steel
Holding Power: (These anchors are not suitable for soils denser than class 5.)	
Class 5 soils *	3,000 kg (6,500 pounds)
Class 6 soils *	1800 kg (4,000 pounds)
Class 7 soils **	909 kg (2,000 pounds)

* See **Table 6** for soil class descriptions
** In class 7 soils, it is advisable to place anchors deep enough to penetrate to underlying class 5 or 6 soil.

Table 7A: Specifications for 203 mm (8 inches) diameter Screw-In Anchors

	203 mm (8 inches) Anchor
Helix diameter:	203 mm (8.0 inches)
Length Overall:	1.65 m (66 inches)
Rod diameter:	25 mm (1 inch)
Material:	Galvanized steel
Holding Power: (These anchors are not suitable for soils denser than class 5.)	
Class 5 soils *	44.5 kN (10000 pounds)
Class 6 soils *	31.1 kN (7000 pounds)
Class 7 soils **	17.8 kN (4000 pounds)

* See **Table 6** for soil class descriptions
** In class 7 soils, it is advisable to place anchors deep enough to penetrate underlying class 5 or 6 soil.

Arrowhead Anchor description

Arrowhead anchors can penetrate stiff and rocky soils because the unique triangular design threads its way between obstacles such as rocks, which can prevent successful installation of screw-in anchors. Arrowhead anchors are driven into the ground with a hardened steel drive rod. Once in the ground, upward force on the attached cable rotates the anchor perpendicular to the cable for maximum holding power.

Table 8: Specifications for Arrowhead Anchors

Length Overall:	1.22 m (48.0 inches).
Arrowhead Length:	203 mm (8.0 inches)
Materials:	6.35 mm (0.25 inches) galvanized (7x19) steel cable; breaking strength - 1905 kg (4200 pounds); with malleable iron head.
Holding Power:	
Class 3 soils *	1905 kg (4200 pounds)
Class 4 soils *	1361 kg (3000 pounds)
Class 5 soils *	907 kg (2000 pounds)
Class 6 soils *	544 kg (1200 pounds)
Class 7 soils *	272 kg (600 pounds)

* See **Table 6** for soil class descriptions

** In class 7 soils, it is advisable to place anchors deep enough to penetrate underlying class 5 or 6 soil.

Rock Anchor description

Rock anchors are placed into solid rock, when anchoring to either bare rock, or thin soils with solid rock near the surface. They are constructed of a threaded rod with integral eye, and two opposing wedge halves. The anchor is placed in a hole pre-drilled in the rock. Twisting the eye of the anchor forces the wedges against the sides of the hole and locks the anchor in place. Load actually increases the wedging force, developing holding power equal to the full tensile strength of the rod.

Table 9: Specifications for Rock Anchors

Holding Power:	9072 kgf (20,000 pounds)
Rod Length Overall:	0.38 m (15 inches), 0.76 m (30 inches) or 1.35 m (53 inches), other lengths available
Anchor Diameter:	44 mm (1.75 inches) as supplied, 60 mm (2.375 inches) max. expanded
Rod Diameter:	19 mm (.75 inches)
Materials:	Malleable iron, dipped in rust-resisting black paint
Required Hole Size:	50 mm (2 inches) diameter (nominal)
Use Rock Drill Size:	50 mm (2 inches) diameter

Concrete Anchor description

The most common alternative anchoring system is to place site-built concrete anchors. A hole is excavated at the anchor position. Reinforcing steel is placed in the hole. A screw-in anchor is often tied into the reinforcing steel to provide a rod and eye above ground to attach the guys. Concrete is poured in place to form the anchoring mass, and the hole is then back-filled.

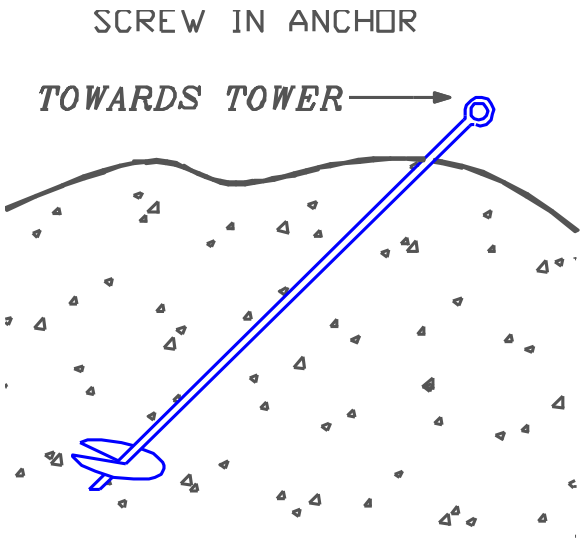
The anchors must be placed carefully to provide anchor points at the proper locations for the tower. **The holding power of concrete anchors is essentially due to their weight. The weight of concrete placed must exceed the required anchor holding force. Concrete anchors still depend on the soil to prevent the concrete mass from shifting toward the tower under load.**

As with all anchoring systems, it is your responsibility to ensure that the anchors will perform as required. If in doubt, seek professional advice for anchor design.

Installing Screw-In Anchors

Note: Unlike a tent stake, screw-in anchors are installed in line with the pull of the guy wires from the tower. It is important to install the anchor at an angle, so the eye of the anchor is toward the tower and the helix screws in away from the tower. If the anchor is incorrectly installed straight into the ground, the load will bend the rod and pull it through the ground, allowing the guys to go slack. Refer to the appropriate stamped drawing in the Appendix to determine the angle of the tower guys from the ground.

Figure 9: Installing Screw-in Anchors



Screw the anchor into the ground by placing a stout bar through the eye of the anchor, and rotating clockwise. It is sometimes helpful to start the anchor into the ground straight down for the first turn, then push it down to the correct angle and complete the installation. Continue screwing the anchor into the ground until about 150 mm (6 inches) of the anchor rod remains above the ground.

If the anchor cannot be installed due to rocks in the soil, or other obstacles, try placing the anchor as much as 1 m (3 feet) from its ideal position to avoid the obstacle, or replace the screw-in anchor with the correct anchor for the soil. Arrowhead anchors are often suitable for rocky soils.

If necessary, a hole can be dug for the screw-in anchor to the proper installed depth, the anchor placed in the hole, and the hole back-filled. The earth must be tamped onto the anchor hard while back filling. The holding power of an anchor placed this way will not be as great as an anchor screwed into undisturbed soil. If in doubt, get professional advice on whether this option will work for your site.

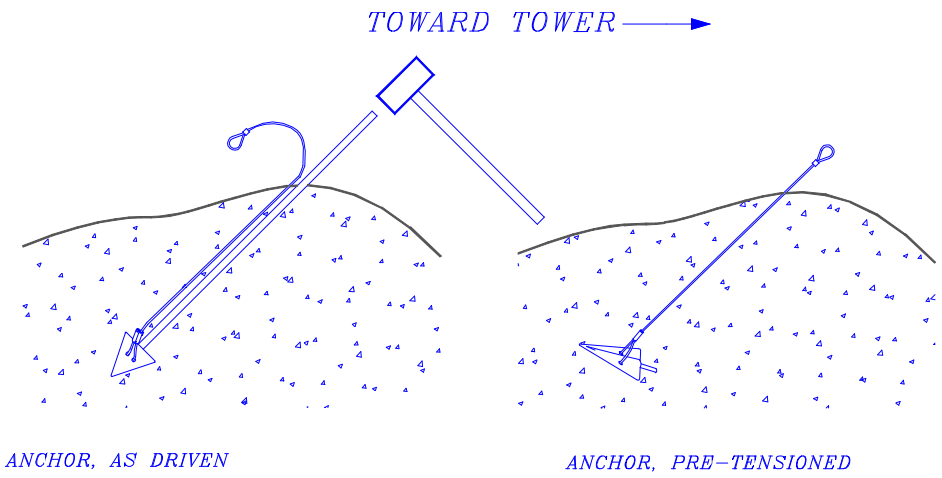
Installing Arrowhead Anchors

Arrowhead anchors are designed for all soils but are especially effective in rocky soils. The arrowhead anchor is driven into the soil with a drive rod. The rod is removed and the anchor is left in the ground. Then the anchor must be pre-tensioned which will cause the anchor to rotate in the ground and develop its full holding potential.

Like screw-in anchors, the arrowhead anchor must be placed so the force from the guy wires pulls directly on the anchor. Drive the arrowhead anchor away from the tower at an angle into the ground. Refer to the appropriate stamped drawing in the Appendix to determine the angle of the tower guys from the ground.

Note: It is important to drive the anchor at an angle. If the anchor is incorrectly installed straight into the ground, the load will result in the anchor cable cutting through the ground until the angle is correct, resulting in significant slack in the tower guys, and possible tower failure.

Figure 10: Installing Arrowhead Anchors



To install the anchor, place the drive rod over the anchor's shank. Drive the anchor into the soil using a sledgehammer, fence post driver, or power jackhammer, until the cable eye attached to the anchor is 50 mm (2 inches) to 100 mm (4 inches) above the surface of the ground.

After the anchor is driven, remove the drive rod, leaving the anchor in the ground. The anchor must now be pre-tensioned by applying strain to the cable. This can be done using a lever, come-along, jack, or winch. Pre-tensioning causes the anchor to rotate in the ground and develop its full holding power. The pull distance will be approximately the length of the anchor head, 203 mm (8 inches). The tension should become significantly higher as the pre-tensioning is complete.

Note: The anchor must be properly pre-tensioned before attaching the tower guys. If it is not, the tower guy wire tension will turn the anchor later, resulting in significant slack in the guy wires and possible tower failure.

Installing Rock Anchors

Rock anchors are used when anchoring to either bare rock or thin soils with solid rock near the surface. Like any anchor, rock anchors must be placed so the force from the guy wires pulls directly on the anchor. Drill the hole for the anchor away from the tower at an angle into the ground.

Note: It is important to install the anchor at an angle, so the eye of the anchor is toward the tower and the expanding part of the anchor points away from the tower. If the anchor is incorrectly installed straight into the ground, the load will bend the rod and pull it through the ground, allowing the guys to go slack. Refer to the appropriate stamped drawing in the Appendix to determine the angle of the tower guys from the ground.

To install the anchor, a hole must be pre-drilled in the rock by hand or power tool. The hole must be 50 mm (2 inches) in diameter, and the walls of the hole should be smooth in the area that the anchor will wedge.
Place the anchor in the hole. Using a bar through the eye of the anchor, turn clockwise to tighten. The anchor will expand and wedge into the hole.

After placing the anchor, fill the hole around the rod with expanding cement grout. One brand is "Rockite" made by Hartline Products Co, Cleveland, OH, USA (telephone: +216 291 2303). Always grout rock anchors to prevent water from collecting and freezing in the drilled hole. Grouting also increases the anchor's holding strength.

Appendix C: Site Visit Procedures

Site Checklist

When making a site visit, check the following:

- Make sure the tower is straight. Stand at the base of the tower and look up to identify any bowed sections or curves in the tower that may have developed since the tower installation. Carefully adjust guy wires as necessary to straighten the tower.
- Check guy wires for excessive slack and adjust as necessary. It is normal for guy wires to stretch over time, and it is especially important to adjust them before they are subjected to icing or high winds.
- Check each anchor for movement or loosening. A loose anchor can also cause excessive slack in guy wires.
- Check that mounting booms, cellular antennas, temperature sensors, etc. are securely attached.
- Confirm that all grounding connections on the tower and on the logger are secure and haven't corroded.
- Check instantaneous sensor readings on each channel of your data logger. Any sensor providing erroneous readings should be disconnected from the logger and tested independently and/or replaced. It is a good idea to always have spare sensors, memory cards, batteries, and a spare data logger!
- Change the data logger's batteries. Remember that batteries are cheap – it's better to change them prematurely rather than risk losing data!

Appendix D: Glossary

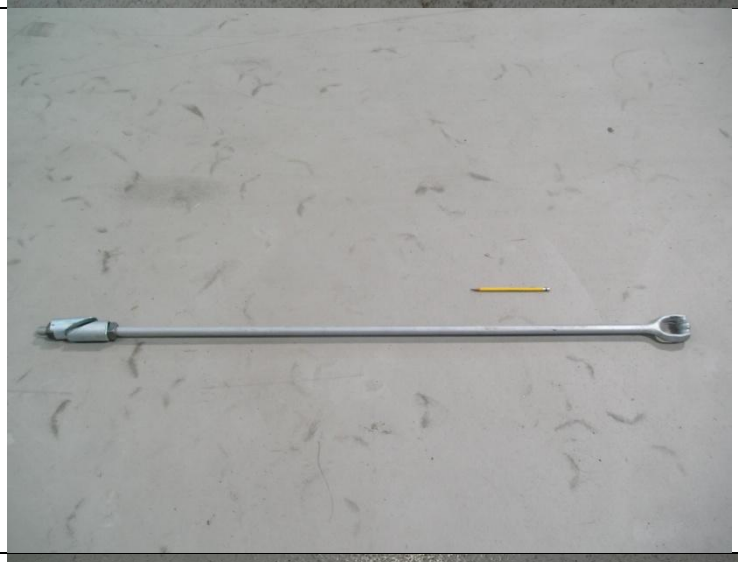
Anchor eye		
Arrowhead anchor		
Base tube (Same as Ginpole Base Tube)		

Base tube, Ginpole base tube, and Helper Ginpole bolt and nut: ¾” x 8” bolt	
Baseplate gusset	
Drive rod for arrowhead anchor	

Ginpole base tube (Same as Base Tube)	
Ginpole guy ropes: 45.7 m x 13 mm (150 ft. x ½ in.)	
Ginpole safety cable	

Ginpole top tube	
Helper Ginpole	
Guy ring	

Guy wire	
Hankmaster	
Lifting wires	

Quick Link	
Rock anchor	
Rocker plate	

Screw-in anchor		
Shackle		
Wire rope clip		

Appendix E: Aligning Wind Vanes

Introduction

Wind Vanes measure wind direction relative to the orientation of the fixed base on the sensor. This Application Note gives you the information you need to orient your wind vanes correctly when they are mounted to the tower. This note also includes information on using Offset and Magnetic Declination corrections when scaling your data to obtain properly scaled and oriented data.

Magnetic Declination

Since the earth's magnetic field is not uniform, the magnetic poles do not coincide with the true geographic poles. Moreover, a compass generally doesn't point to a true geographic pole; it points to a magnetic pole. This difference between a true geographic bearing and a magnetic bearing varies from location to location and is called *magnetic declination*. Magnetic declination or "compass variation" is the horizontal angle between *true north* (also called "geographic north" or "map north") and the direction the compass points, *magnetic north*.

Magnetic declination is measured as the number of degrees of error a compass shows at a site. The declination for sites located east of the magnetic north pole is expressed as the number of degrees that magnetic north is west of true north. The declination for sites located west of the magnetic north pole is expressed as the number of degrees that magnetic north is east of true north. For example, Vermont (USA) has a magnetic declination of 15 degrees west. In other words, magnetic north in Vermont is 15 degrees to the west of true north. Magnetic north in Fairbanks, Alaska (USA) is about 27 degrees east of true north; therefore, its magnetic declination is 27 degrees east.

The earth's magnetic field varies slightly in position over time. Therefore, the magnetic declination at a site also varies over time. Because of this variation, it is important that you reference an up-to-date map of declination ("isogonic map") if you choose to orient your wind vanes to magnetic north. Later you can enter a correction for magnetic declination into your wind data analysis software if desired.

Mounting and Aligning Wind Vanes

Since a magnetic compass is the simplest direction reference, it is sometimes convenient to orient wind vanes in the field to magnetic north. Most NRG customers, however, align their wind vanes to true north. Before installing your NRG logger, decide whether you want wind direction data to report north when the wind is from the *magnetic north* or when the wind is from *true north*. Be sure to make note of your choice and maintain consistency among your sites and projects.

To align a wind vane to true north:

1. Use a transparent orienteering compass with a rotating bezel and magnetic declination markings. In the example in Figure 1, 15 degrees west means that the direction of the compass needle (magnetic north) lies 15 degrees west of true north.

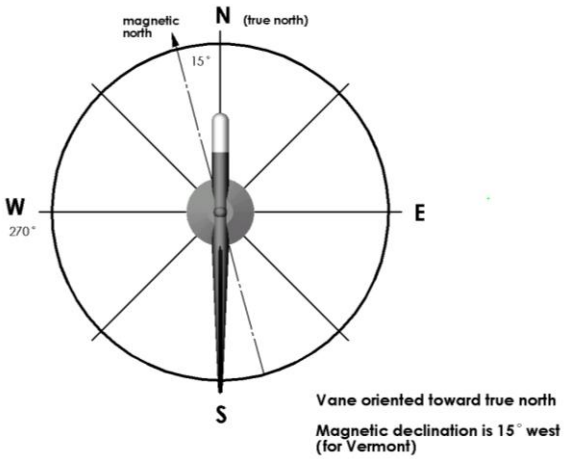


Figure 1

NOTE: Lining up the ridges on the body of the wind vane will cause the sensor to indicate a north reading. Be sure to keep this in mind when orienting the wind vane on the mounting boom.

2. Stand so that it is possible to sight along the tower from the top to the base. Align the bearing mark on the compass so that it points directly in line with the tower, top to base. The bearing of the TallTower in the example in Figure 2 is 270 degrees.

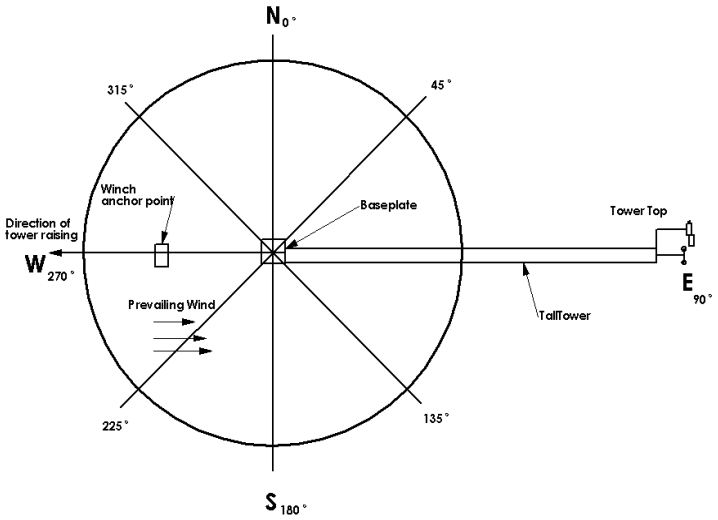


Figure 2

3. Without moving the base of the compass, rotate the bezel so the north end of the needle points to the declination mark that corresponds to local declination.

4. Loosely attach the mounting boom to the TallTower. Lift the compass to a vertical position so the bearing mark points straight up. Use a level if necessary.

5. Sight through the compass so the center of the compass is over the point where the boom contacts the tower, with the bearing mark still straight up. See Figure 3.

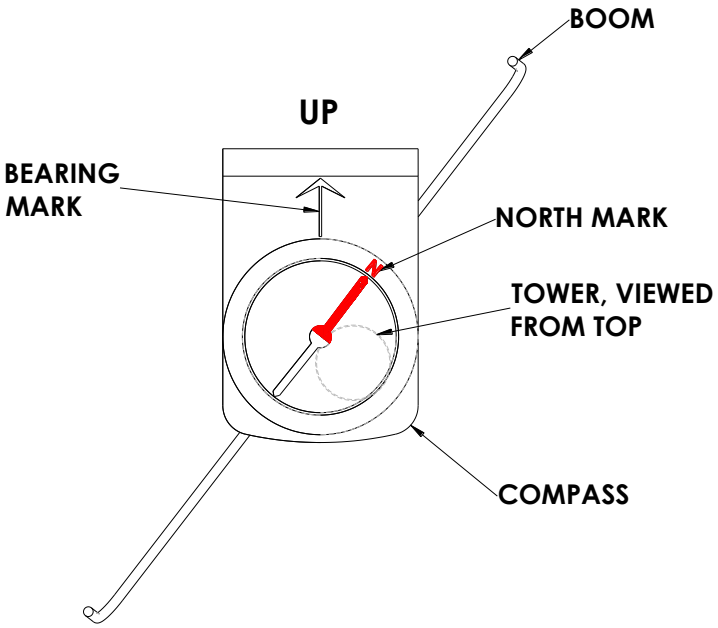


Figure 3

6. Have a crew member rotate the boom until it aligns with the north mark on the compass, and tighten the boom.

7. Attach the wind vane with the north arrow index mark on the base pointing in the same direction as the north mark on the compass. The #200P wind direction vane is designed to mount with a cotter pin and set screw to a NRG sensor mounting boom. The cotter pin installs horizontally through drill holes in the boom and vane, allowing the base of the vane to point in one of two directions, toward the tower or away from the tower. See Figure 4.

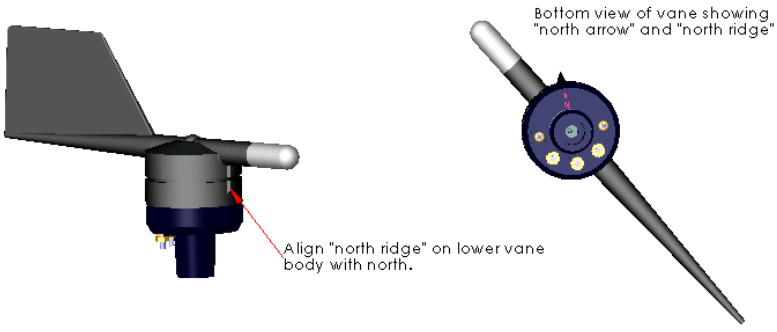


Figure 4

8. When you raise the TallTower, the north arrow on the base of the wind vane will point to true north.

9. Use the compass to verify your settings. If necessary, adjust the position of the mounting boom before raising the TallTower.

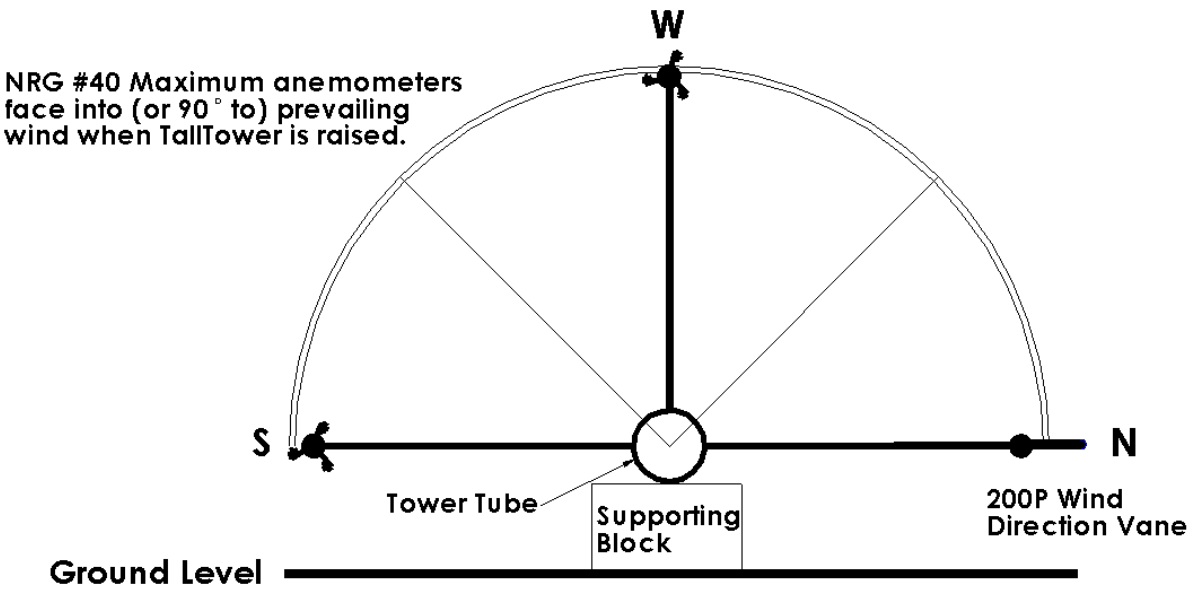


Figure 5

Using Data Analysis Software to Correct for Magnetic Declination

If you orient your wind vanes toward magnetic north but want the direction data reported relative to true north, enter the magnetic declination for the site into the offset or magnetic declination field in your wind data analysis software. NRG's BaseStation Software, for example, has a field called **Mag Declin.** BaseStaion applies the declination to all wind direction data for the site if the Mag Declin field is set to anything but zero. **Declination is not needed if you orient your wind vanes to true north.**

Note: Wind direction vanes have a small range centered around the sensor's north reading that is called the dead band and produces a zero reading. Although NRG Loggers have an algorithm that interprets north readings correctly, when the prevailing wind is from the north, it may make sense to orient the vane to a direction other than north. If you do this, compensate for the orientation by entering a value in the wind vane 'offset' field of your data analysis software. For example, if you orient your wind vane to the south (180 degrees), enter an offset of 180 for the vane.

Note: If you orient your wind vane to a magnetic bearing other than magnetic north, you need to enter values for both magnetic declination and offset in your data analysis software. Enter the site's magnetic declination so that your software can compensate for the declination; enter an offset to compensate for the orientation of the vane. If just one offset field is available in your software, such as NRG's Symphonie Data Retriever software, you will need to combine the magnetic declination value with the offset value (if wind vanes are not oriented to true north) and enter the net value. For example, if your wind vanes are oriented to the south instead of north, and your site has a magnetic declination of 15 degrees west, you would enter 165 (or -195) in the offset field. Declinations to the west of true north are subtracted from the magnetic reading, and declinations to the east of true north are added to the magnetic reading.

Appendix F: Hankmaster Tool for Unrolling Guy Wires

The guy wire and lifter coils can be unrolled using the convenient Hankmaster tool. A Hankmaster can be built from materials available from most hardware stores using a few simple tools.

Materials
1x 41.5” (105.4cm) of 1.625” (4.127cm) OD PVC Pipe, cut into:
1x 17” (43.18 cm) section;
1x 15” (38.1 cm) section;
1x 5.5” (13.97 cm) section;
1x 4” (10.16 cm) section.
2x 90 degree PVC Elbow Socket Fittings 2” (5.08 cm) OD
1x PVC T Socket Fitting 2” (5.08 cm) OD
1x Squared Retainer Snap Safety Pin, 2.5” (6.35 cm) usable length
2x 28” (71.12 cm) diameter x 0.5” (1.27 cm) thick plywood
8x 0.375”-16x3.5” Hex Head Bolts (M10 x 90 mm)
8x 0.375”-16 (M10) Nuts
8x 0.625” OD x 1.5” length (10 mm OD x 90 mm length) Spacers

Tools
Saw
Drill
0.375” (M10) drill bit
2x 3/8 (10 mm) Wrenches or equivalent
PVC Adhesive (Used for all PVC pipe connections)

Procedure
Connect (quantity 1) Elbow Socket Fitting (part #2) onto 17” (43.18 cm) section of 1.625” (4.1 cm) OD PVC Pipe (part #1a).
Connect T Socket Fitting (part #3) onto other end of 17” (43.18 cm) section of PVC pipe (part #1a).
Connect 15” (38.1 cm) section of PVC pipe (part #1b) onto T Socket Fitting (part #3) in line with the 17” (43.18 cm) section.
Connect other (quantity 1) Elbow Socket Fitting (part #2) onto other end of 15” (38.1 cm) PVC pipe (part# 1b).
Drill a hole through the 5.5” (13.97 cm) PVC Pipe (part #1d) 0.5” (1.3 cm) from the end of the pipe section.
Connect 5.5” (13.97 cm) PVC Pipe (part #1d) onto other end of the second Elbow Socket Fitting (part #2).
Drill two holes through the 4” (10.16 cm) PVC pipe (part #1d), through the same plane, 1.5” (3.8 cm) from the end of the pipe.
Cut a 3/8” slot from the end of the 4” (10.16 cm) PVC pipe (part #1d) through the holes (step #7).
Connect 4” (10.16 cm) PVC Pipe (#1c) into remaining point of T-Fitting (part #3).
Cut 2” (5 cm) holes through the center of the 2 plywood discs (part #5).
Drill (8) 3/8” holes evenly around the 2 plywood discs (part #5) with a 10.5” (26.7 cm) radius.
Place the (quantity 8) bolts (part #6) through the 8 holes drilled in one of the plywood discs (part #8).
On the bolts (part #6) on the other side of the plywood disc (part #8), place the (quantity 8) spacers (part # 8) followed by the (quantity 8) nuts (part #7) tightened snugly.
Line up the holes on the other plywood disc (part #5), and put the two discs on the 5.5” (13.97 cm) PVC Pipe (part #1c).
Insert the Safety Pin (part #4) in the hole drilled through the 5.5” (13.97 cm) PVC Pipe (part #1c) to complete assembly.

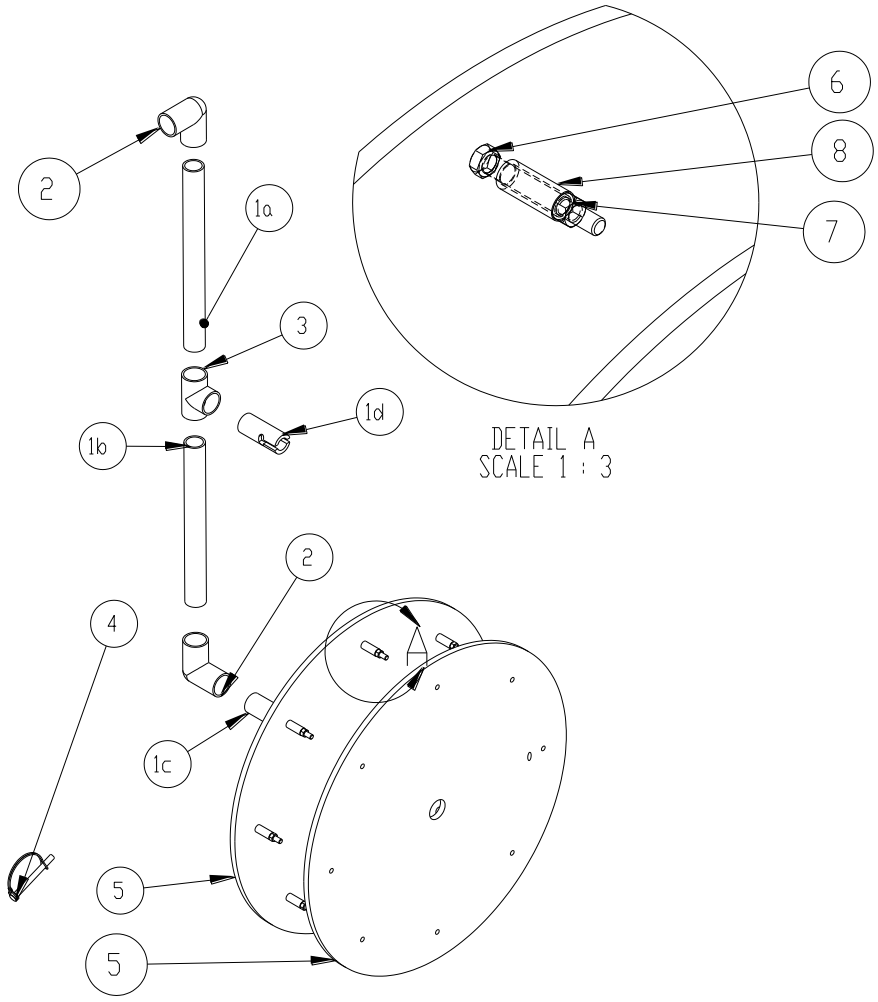


Figure 1. Completed Hankmaster 5000™

Usage
Unclip Safety Pin, remove from pipe.
Remove outer plywood disc.
Lay Hankmaster 5000™ on its side with the handle facing down.
Place coiled guy wire onto inner disc, around the 8 bolts.
DO NOT UNCLIP GUY WIRE COIL UNTIL YOU HAVE FINISHED ROLLING IT OUT TO THE ANCHOR.
Roll Hankmaster 5000™ to appropriate Guy Ring of tower.
Unclip guy wire coil; attach clip to guy ring.
Unroll guy wire coil to the appropriate anchor.
To re-coil a guy wire, simply thread guy wire through the angled hole in the outer plywood disc, and roll Hankmaster 5000™ over guy wire.
While rolling, guide guy wire through the wire guide above the plywood discs.
When coiling is complete, use a rubber band to hold the coil and prevent unspooling.
Lay Hankmaster 5000™ on its side with the handle facing down.
Remove coiled guy wire.

Index

"Inchworm" method 31
alternative anchoring 48
anchor placement 15, 49
anchor radii 14
anchor requirements 45
anchoring 6, 8, 14, 15, 35, 45, 47, 48, 49, 50, 51
Anchoring Guidelines 45
anchoring in solid rock 48
anchoring the baseplate 17, 18
anchors 6, 8, 14, 15, 19, 37, 45, 46, 47, 48, 49
Anchors 14
arrowhead anchors 47, 49
arrowhead anchors, installing 50
arrowhead anchors, pre-tensioning 50
base plate 8, 14, 15
base tube 20
baseplate 8, 14, 15, 16, 17, 19, 20, 25, 28, 34
batteries 51
cement grout 50
concrete anchors 45
coupler plates 26, 27
drive rod 47
electrical tape 21
gin pole assembly 25
ginpole ropes 27
Ginpole Tilt-Up 30
glossary 52
ground wire 21
gussets 17
guy guards 37
guy ring corners 20
guy rings 13, 19, 20, 22, 24, 30
guy wire tensioning 31
guy wires 22
guys 15, 34, 36, 37, 48, 49, 50
Hankmaster 9, 22, 23, 56, 63, 64
helper ginpole 25, 28, 39
icing 37, 45, 51
installing arrowhead anchors 49
installing rock anchors 50
lifter wires 24, 28
lifters 22, 24, 30, 34, 35
Magnetic Declination 59
oil on tower joints 20
pivot pipe 20, 25
pre-lift 14
pre-tensioning arrowhead anchors 50
quick release pin 20
rock anchors 48
rock anchors, installing 50
safety 6
safety cable 25, 26, 54
screw-in anchors, installing 49
sensor cables 21
settling 37
shackles 22, 30
Site Layout 14
site visit procedures 51
site-built anchors 45
slack in guy wires 34, 49, 50, 51
soil 6, 8, 45, 46, 47, 48, 49, 50
soil type 45
straightening the tower 36
stretch, guy wires 37
TallTower installation on a slope 15
tension, guy wire 15, 31, 34, 35, 50
tools 8
Tower Lowering 38
Tower Tilt-Up 31
transferring the lifting guys 35
tube layout 19
unpacking 11
WARNINGS 6
winch 8, 9, 14, 15, 27, 34, 35, 38, 39, 50, 55
winch anchor 14
wind vane alignment 59
wire rope clips 8, 24, 31, 33, 34, 35, 37